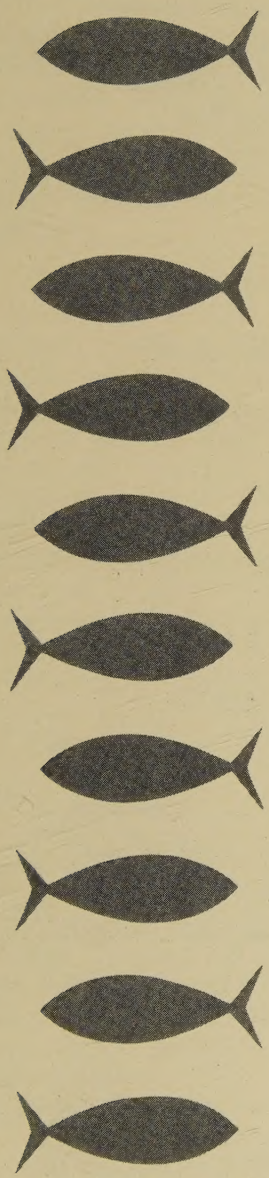
Southwest FISHERIES SCIENCE CENTER

HONOLULU LA JOLLA MONTEREY TIBURON

REPORT OF ACTIVITIES November-December 1993



ANTARCTIC ECOSYSTEM RESEARCH GROUP Page

1993-94 Antarctic Marine Living Resources Field Season Begins 1

COASTAL FISHERIES RESOURCES DIVISION

Study Made of Effects of Ultraviolet Solar Radiation on Pelagic Fish Eggs and Larvae 2

MARINE MAMMAL DIVISION

PODS93 Survey 5

HONOLULU LABORATORY

Workshop Held on Marine Turtle Hooking Mortality 11

PACIFIC FISHERIES ENVIRONMENTAL GROUP

CEOS Program Studies Potential Effects of Global Climate Change 15

PELAGIC FISHERIES RESOURCES DIVISION

13th North Pacific Albacore Workshop Held 17

TIBURON LABORATORY

Offshore Trawl Surveys and Nearshore Direct Observations Compared to Estimate Year-class Strength of Blue and Yellowtail Rockfish 19

INFORMATION TECHNOLOGY SERVICES

IT-95 System Execution Phase Begins 21

PUBLICATIONS

List of 1993 Publications 21

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

1993-94 Antarctic Marine Living Resources Field Season Begins

During November and December, the Antarctic Ecosystem Research Group (AERG) was preparing for the Antarctic Marine Living Resources (AMLR) program's 1993-94 field season in the Antarctic. This year, as for the past five seasons, AMLR field research is being conducted in the vicinity of Elephant Island, which is part of the South Shetland Islands at the tip of the Antarctic Peninsula. As in the past, the field effort includes research conducted from aboard the NOAA Ship *Surveyor* and at a field camp on Seal Island, a small island off the northwest coast of Elephant Island.

The keystone of the Antarctic pelagic ecosystem is Antarctic krill, *Euphausia superba*, which sustains multitudes of seals, penguins, whales, squid, and other Antarctic marine life. Krill are also harvested by a multinational commercial fishery, part of which is located in the Elephant Island area. Many penguin and fur seal breeding colonies are also located in this area, causing concern that the krill fishery could adversely impact these breeding krill predators. The AMLR field program is designed to describe the functional relationships between the krill, their predators, and key environmental variables in the Elephant Island area. Ultimately, CCAMLR's goal is to manage the krill harvest so the impact on these animals will be minimized. During past cruises, shipboard mapping of the waters around Elephant Island indicated that several water masses converge in the area, forming a hydrographic front along the shelf break north of the island. High densities of phytoplankton and krill are associated with the position of the frontal zone although the seasonal timing of their appearance can vary by several weeks. This year's field program will continue to combine descriptive surveys of the pelagic ecosystem in the Elephant Island area and more focused studies of selected processes.

The Seal Island field camp was activated this season on November 30, 1993, when the first field team arrived via the *Explorer*, a private tourist ship. This team includes Peter Boveng, John Jansen, William Meyer, Michael Schwartz, and Brian Walker, all of the National Marine Mammal Laboratory (NMML). During the season, new NMML personnel will arrive via the *Surveyor* to exchange places with original team members: Lisa Hiruki will arrive in early January, and Boveng and Jansen will leave the camp in early February. Throughout the season, the scientists will be studying the reproductive and foraging behaviors of penguins and seals breeding on the island. The field team will remain on the island through mid-March, when the final members are retrieved by the *Surveyor*.

The NOAA Ship *Surveyor* will depart from Punta Arenas, Chile, on January 12, 1994, to begin the first of two 30-day legs. During each leg, a large-area survey will be conducted to map mesoscale (10s to 100s of kilometers) features of water mass structure, phytoplankton biomass and productivity, and zooplankton constituents in the area around Elephant Island. A small-area survey to map the microscale (1 to 10s of kilometers) features of the distribution, density, and abundance of krill immediately north of Elephant Island will also be conducted during each leg. In addition, acoustic transects north of Elephant Island, east of Clarence Island, and across the Bransfield Strait will be made during both legs.

During Leg I, a survey of the distribution and abundance of Antarctic fur seals in the vicinity of Elephant Island will be conducted. The objectives of this survey are to count fur seal pups at known breeding colonies and to document any new colonies that have formed since the last comprehensive survey in 1986/87. In addition, this season will feature a new experiment using a small buoy equipped with a radar reflector and drogue. The free-floating buoy will be deployed within a krill swarm, and side-looking and down-looking acoustic observations will be made of that krill swarm while transiting a search pattern relative to the position of the buoy for a 2-day period. In this way, it is hoped that the movement of a krill swarm, both laterally and vertically, can be described.

The Antarctic cruise will be completed on March 15, 1994, when the *Surveyor* returns to Punta Arenas, Chile. Scientific personnel will return home, and the ship will proceed with her northbound transit, returning to Seattle on April 26, 1994. (J. Rosenberg, [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Study Made of Effects of Ultraviolet Solar Radiation on Pelagic Fish Eggs and Larvae

Leader Russ Vetter and other scientists in the Genetics and Physiology program at Southwest Fisheries Science Center have been investigating the effects of ultraviolet solar radiation on pelagic fish eggs and larvae under natural solar conditions. UV-B, the portion of the solar spectrum between 280-320 nanometers, is a high-energy form of solar radiation that can damage biological systems through a number of different mechanisms. The primary mechanism is damage to DNA with subsequent problems associated with mutation, gene transcription, and cell regulation. The amount of UV-B radiation reaching the earth is thought to be increasing due to depletion of atmospheric ozone. Ozone depletion was thought to be a polar phenomenon but recent measurements indicate that there has been significant thinning of ozone over the north temperate zone.

Previous studies carried out by Coastal Fisheries Resources Division Chief John Hunter documented the effects of UV-B radiation on growth and survival of larvae of northern anchovy, *Engraulis mordax*, that were exposed to natural and artificial UV-B in laboratory experiments. However, the experimental endpoints (growth depression and decreased survival) are general indicators of stress that cannot be used in the field to test for UV effects.

One form of DNA damage (the thymine-thymine pyrimidine dimer) is caused only by UV-B radiation. Vetter and the other scientists have used a monoclonal antibody linked to a detection system to test for the presence of this type of DNA damage in naturally occurring pelagic fish eggs. By collecting eggs at different seasons, depths, and times of day, they hoped to show a direct link between solar UV-B irradiance and the amount of DNA damage in eggs and larvae.

Figure 1 shows the diel pattern of DNA damage and repair in northern anchovy eggs that were spawned in the laboratory, then exposed to natural sunlight on the roof of the laboratory. DNA damage was greater at 100 percent than at 50 percent sunlight. Damage increased throughout the morning, reaching a maximum at about solar noon. The amount of damaged DNA decreased during the afternoon even though UV-B was present (although

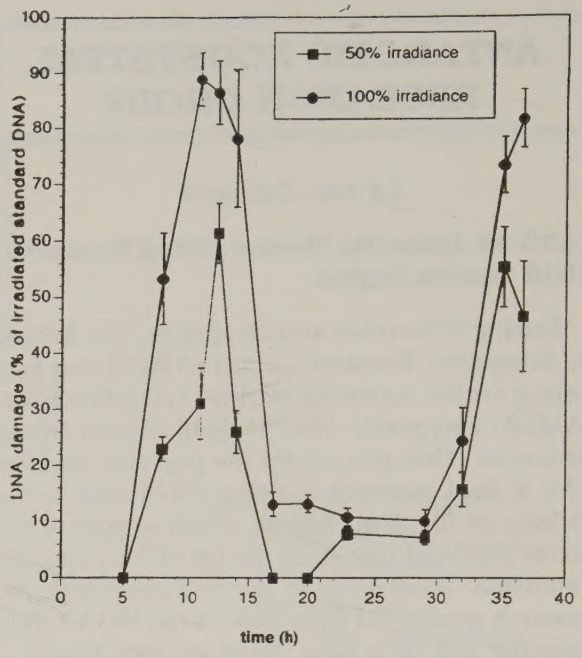

Figure 1. Stage III anchovy eggs were exposed to 50 percent and 100 percent natural sunlight for 1-1/2 days (5:00 a.m., November 3, 1993, to 12:30 p.m., November 4, 1993, La Jolla, California).

at ever-diminishing concentrations). This indicates that photorepair processes were activated and that the rate of repair began to overtake the rate of damage. Anchovy embryos are apparently able to repair the thymine dimers, reverting them to two adjacent thymine monomers, using a light-dependent process called photoreactivation. This type of experiment was the basis for interpreting dimer concentrations in field samples.

Figure 2 shows the same diel cycle of damage and repair in anchovy eggs in Manta tow samples taken at different times of the day. Again, damage increased until noon, then decreased in the late afternoon. The variance in field samples was greater than in the roof experiments, suggesting that the source of variance may have been due to differences in individual dose, caused by vertical mixing, as well as variability associated with the measurement of dimers. The scientists also found a decrease in DNA damage with depth in the water column and a difference between the amount of damage in eggs of different species (Fig. 3). In a vertical series of samples taken with the Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS), eggs of Pacific sardine, *Sardinops sagax*, appeared to have consistently higher levels of dimers than anchovy, but both species had decreasing levels of dimers at deeper depths in the water column.

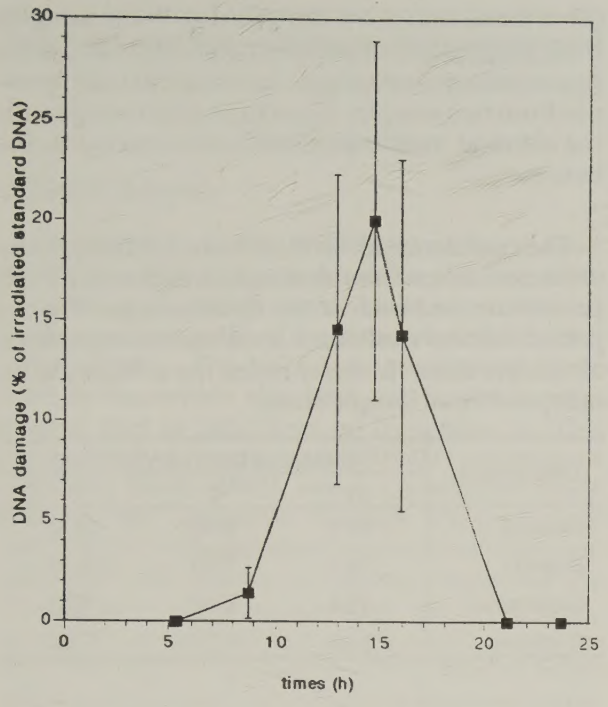

Figure 2. Northern anchovy eggs collected at various times of the day in the Southern California Bight using Manta nets, May 1993.

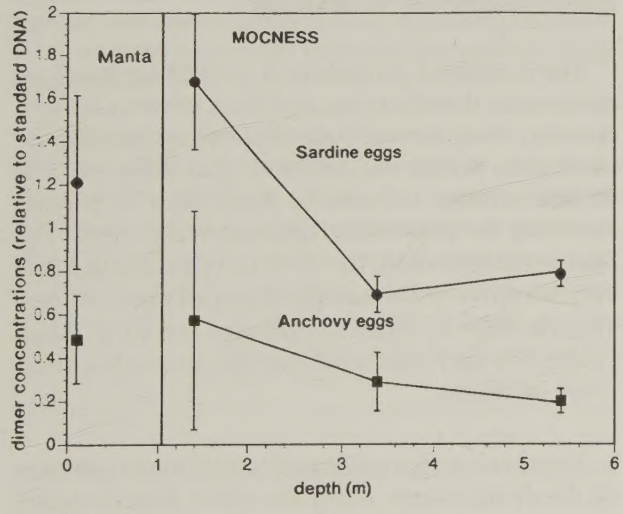

Figure 3. Stratified samples collected at solar noon using Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS; samples >1 meter deep) and Manta nets (samples <1 meter deep). Dimer concentrations in northern anchovy and Pacific sardine taken from the same nets were determined by the monoclonal antibody technique. Each point is the mean number of dimer concentrations found in replicate samples (from between three and six each) from the same net. Each sample contained three eggs.

These studies are the first to document actual UV-B-related DNA damage in natural populations of marine fish eggs. They show conclusively that even present-day levels of UV-B can potentially damage eggs and larvae. However, they also show that marine fish eggs have a remarkable capacity to repair damage. In addition, pelagic eggs and larvae are often distributed over a wide depth range. Given the rapid attenuation of UV-B in seawater, it is quite possible that the effects of UV-B are small relative to other sources of mortality. Future studies will attempt to determine the lower depth limits for DNA damage under different optical conditions in the water column (dissolved organic carbon and chlorophyll). Vetter and the other scientists also intend to compare specific levels of UV-B exposure to specific increments in growth so that the potential effects of increased UV-B can be modeled. (R. Vetter, [619] 546-7125)

Simulation Study Used to Examine Two Commonly Used Procedures for Comparing Mean Values

Statistician Nancy Lo recently completed a simulation study which shows that the two commonly used procedures for comparing population means do not always give the intended result.

In scientific literature, summary statistics such as averages and standard errors are usually used to construct confidence intervals (CI) for the true mean, under the assumption of the normal distribution of the sample mean. These CIs are frequently used to compare the two true averages in the following two ways: (1) If two 95-percent CIs are overlapping, one concludes that the two population means are not statistically different; (2) when only one CI is available, one concludes that the two means are not statistically different if one sample mean is within the 95 percent CI of the other mean.

Lo notes that these two procedures are convenient ways of making inferences about the population parameters, but the level of significance (α) of these two procedures does not always equal the intended 5 percent. According to Lo, the correct statistical procedures should be those based on the difference of two sample means, for example, t statistics and the CI for the difference of two population means (CI[d]). In her simulation study, Lo computed the actual confidence level ($1-\alpha$) and the power of these two procedures and compared them to the CI(d) computed from the difference of sample means. Note that both the level of significance (α) and the power are probabilities of claiming that the two population means are statistically different, except that α is computed when two population

means are the same, and the power is computed when the two population means are different. When CI(d) is used, and the CI(d) contains zero, one may conclude that the two population means are not statistically different. Now there are three procedures to consider: procedure A is the overlapping of two CIs, procedure B is the inclusion of one sample mean in the CI from the second sample, and procedure C is the CI(d) based on the difference of two sample means. Different statistical distributions were included in the simulation to check how robust the CI(d) is since it is based on the assumption of a normal distribution. The different distributions are normal, Poisson, lognormal, and gamma.

To further explain her simulation, Lo uses a comparison made by Hunter and Leong in 1981 which examines the mean batch fecundity for 15 to 19.9-g northern anchovy (matured in the laboratory and at sea):

Locality	n	mean	(2SE)	95% CI
Laboratory	38	8,910	(1,210)	(7,700; 10,120)
Sea	17	6,800	(1,150)	(5,650; 7,950)
Difference		2,110	(1,669)	(441; 3,779)

One would infer that the two average batch fecundities would not be statistically different if procedure A were used but not if procedures B or C were used. Lo concludes that procedure C is the preferred choice since it is known that the confidence level is 95 percent. However, if A or B must be used, knowledge of the level of significance of the procedure would be helpful to make the final decision.

In Lo's simulation, 1,000 iterations were run for each comparison of 2 population means for sample sizes between 5 and 100. The parameters for each distribution are as follows:

Distribution	Parameters
Normal	mean = 1.0 (H_o),1.5, 2.0, 3.0, 4.0, and 5.0 standard deviation = 2
Poisson	mean = variance = 0.5 (H_o), 1.0, 2.0, 5.0, and 10.0
Lognormal	mean = 0 (H_o), 0.5, 1.0, and 2.0 standard deviation = 1
Gamma	b(scale) = 1.0; c(shape) = 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 (H_o)

where H_o refers to the mean value under the null hypothesis. Samples from the population with other mean values are compared with the samples from the population with the mean value under H_o to compute power values. Lo computed the α values from two samples taken from populations with the identical mean values for each statistical distribution.

The confidence levels (1-α) from 1,000 iterations of the simulation were obtained for each of the three procedures and each of the distributions. The reported value of confidence level was averaged over all sample sizes. In many cases, the α values were independent of sample sizes:

Distribution	Confidence level percent (1-α)		
	A	B	C
Normal	99.3	85.0	95.0
Poisson	94.0	83.0	96.0
Lognormal	99.5	84.0	95.0
Gamma	99.5	82.0	95.0

In conclusion, Lo's simulations show that, as expected, procedure C maintains the assumed confidence level for the four distributions when the sample size is greater than 10. Therefore, CI(d) is a robust procedure to use for the other three distributions if sample size is moderate.

The α value of procedure A is 0.005 for the three continuous distributions, and thus, when A is used, one may tend to conclude that two means are the same even if they are different. But if the two CIs do not overlap, one can be more than 95 percent sure that the population means are different. For Poisson distribution, the α value of procedure A is very sensitive to the sample size and mean values. The α is large for small sample size and small mean values and decreases as the sample size or the mean value increases.

The α value of procedure B is 0.17, averaged over all the distributions, and thus, when B is used, one may tend to conclude that two population means are different when, in fact, the population means are the same. For gamma distribution, the α value of procedure B decreases as the sample size or the mean value increases (especially for a small sample size such as five).

Among the three procedures, procedure B is the most powerful, and option A is the least powerful if the population means are indeed different. (N. Lo, [619] 546-7123)

MARINE MAMMAL DIVISION

La Jolla, California

PODS93 Survey

On November 2, 1993, the NOAA research vessel *McArthur* entered port in Mazatlan, Mexico, after completing a 3-month survey of the area inhabited by the northern stock of the common dolphin, *Delphinus delphis*. The NOAA research vessel *David Starr Jordan*, which also took part in the survey, entered port in San Diego on November 6. This year's survey, referred to as PODS93 (Population of *Delphinus* Stocks 1993), was a cooperative study between the Southwest Fisheries Science Center and SEPESCA (the Mexican Secretariat of Fisheries) and CICIMAR (Mexico's National Center for the Investigation of Marine Sciences). The primary objective of this year's project was to survey the ocean area inhabited by the short and long-beaked forms of the northern stock of common dolphin and make estimates of their absolute abundance. These data are used to assess the impact of dolphins killed incidental to fishing operations in California waters and international yellowfin tuna commercial fishing operations in the eastern tropical Pacific. Other objectives included the collection of physical, biological, and oceanographic data regarding the habitat of marine mammals to better understand their distribution.

The information provided by this year's survey will be useful in determining the status of the two forms of the northern stock of common dolphin relative to their optimum sustainable population level. Previous surveys had not covered the entire range inhabited by this stock, and without reasonable estimates of abundance, status could not be determined. These absolute abundance estimates are important because information obtained from tuna vessel observer data indicates that over the last 10 years there has been a significant decline in the relative abundance of northern common dolphins in the eastern tropical Pacific. The exact cause or causes of this decline in this region is not known, but the results from this year's survey may provide answers. Summaries of the various aspects of the survey follow. (J. Sisson, [619] 546-7064)

Marine Mammal Survey Overview

The survey area extended along the west coast of North America from Cabo Corrientes, Mexico (20.37° N, 105.67° W), to the California-Oregon border (42.00° N, 124.19° W), covering approximately 606,700 square miles and extending about 300 nautical miles offshore. In Figure 1, the study area and the tracklines covered by *David Starr Jordan* and *McArthur* combined are shown. The study area was divided into two strata separated by a line connecting Cabo San Lucas to Cabo Corrientes. Within the Gulf of California, primary transect lines ran north-south approximately 27 nautical miles apart, while secondary transect lines ran east-west 60 nautical miles apart. Along the outer coast, two sets of primary transect lines approximately 150 nautical miles apart ran at bearings of 27° T (true north) and 72° T. The secondary tracklines ran north-south beginning at the 107.5° W meridian at intervals of 2.5°. Primary tracklines were surveyed first, then secondary tracklines were surveyed as weather permitted. *McArthur* covered approximately 4,500 nautical miles of prescribed trackline "on effort" and *David Starr Jordan* covered approximately 5,400 nautical miles.

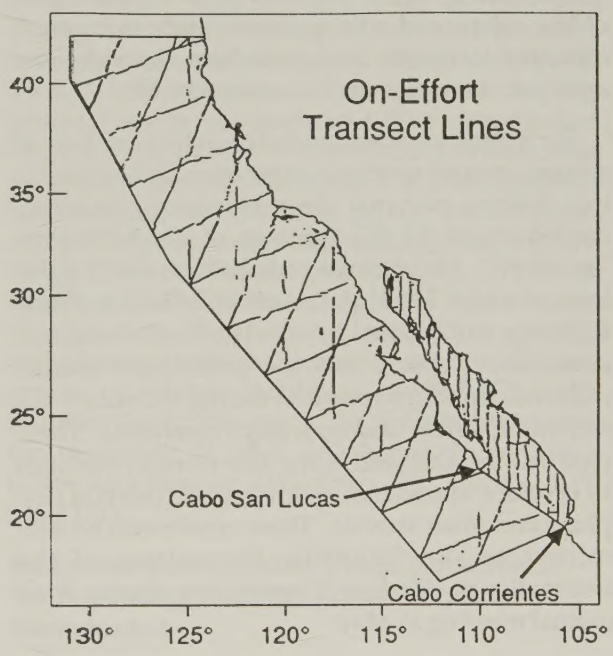

Figure 1. Combined tracklines followed by *David Starr Jordan* and *McArthur* on the 1993 Population of *Delphinus* Stocks survey in California and Mexican waters.

On each vessel, surveys were conducted by maintaining a visual watch during daylight hours using 25-power binoculars mounted to the ship's flying bridge, with a maximum ship-to-horizon sighting distance of approximately 6 nautical miles. Generally, all schools encountered within 3 nautical miles were approached to confirm identification and obtain

school size estimates. Marine mammal survey effort was conducted by two teams of four marine mammal observers. During a watch, the four team members rotated among the following positions at 40-minute intervals: observing at the port binoculars, serving as data recorder, observing at the starboard binoculars, and acting as an independent observer. An event-driven data acquisition system (CRUISE2) was employed to record all environmental parameters and sighting information. The system was comprised of a Toshiba laptop computer linked to the vessel's Global Positioning System (GPS). The independent observer was responsible for detecting any marine mammals missed by the primary observers. If the ship passed the animals without the primary observers making a sighting, only then would the independent observer call out the sighting. For each sighting, the sighting cue, bearing, and distance were recorded. Video cameras were mounted on a 25-power pair of binoculars, and attempts were made to measure distances to marine mammals from the video images that were captured on computer file.

Each observer made an independent estimate of school size and species composition for each sighting. Marine mammal observers aboard *Jordan* recorded a total of 1,072 sightings, of which 780 were "on effort." *McArthur* recorded a total of 632 sightings, of which 506 were "on effort." The "on effort" sightings will be used to calculate final abundance estimates. Table 1 lists the preliminary marine mammal sightings recorded during the survey for *McArthur*, *Jordan*, and both ships combined. These data will be analyzed using line-transect methods to produce abundance estimates for common dolphins and other species. These results will be submitted to the Scientific Committee of the International Whaling Commission during their annual meeting in May.

Southwest Fisheries Science Center (SWFSC) scientists also collected data that will aid in defining marine mammal stock boundaries. To complement the aerial photogrammetry (see below), shipboard photographs were taken to document dolphin body morphology and color patterns, which for example, are known to vary between onshore and offshore animals. Table 2 lists the total number of photographs of each species taken from both ships with hand-held 35-mm cameras during the survey. Eighteen different species of cetaceans were photographed.

Table 1. Cetacean school sighting records for *McArthur* and *Jordan* during the PODS93 survey. The grand total for *McArthur* sightings is less than the total sum of the individual sightings to avoid double counting those in mixed schools.

SPECIES	SIGHTINGS McARTHUR	SIGHTINGS JORDAN
Delphinus delphis (short)	125	51
D. delphis (long)	4	48
D. delphis (unident.)	10	7
Stenella attenuata	2	47
S. attenuata graffmani	0	12
S. attenuata (unident.)	0	19
S. longirostris	0	4
S. longirostris orientalis	5	33
S. coeruleoalba	29	67
Steno bredanensis	2	20
Tursiops truncatus	14	144
Grampus griseus	19	63
Lagenorhynchus obliquidens	12	8
Lissodelphis borealis	9	0
Phocoena phocoena	3	0
P. sinus	0	26
Globicephala macrorhynchus	8	17
Feresa attenuata	0	2
Pseudorca crassidens	0	2
Orcinus orca	3	7
Kogia breviceps	1	1
K. simus	0	30
K. spp.	2	4
Mesoplodon spp.	3	12
M. densirostris	1	0
Unident. *ziphiid*	11	19
Ziphius cavirostris	12	20
Berardius bairdii	5	0
Balaenoptera spp.	21	66
B. acutorostrata	1	1
B. edeni	3	11
B. physalus	1	26
B. musculus	59	23
B. edeni or *B. borealis*	2	17
Megaptera novaeangliae	23	3
Physeter macrocephalus	24	33
Unident. dolphin	39	101
Unident. small whale	12	4
Unident. large whale	14	18
Unident. cetacean	6	15
Unident. whale	3	3
Pinnipeds and Others	93	88
TOTAL	632	1,072

Individual whales can be recognized from photographs of dorsal fins, tail flukes, and body color patterns. Photographs from this cruise will contribute to the growing catalog of individually known

Table 2. Hand-held 35-mm photographic record of cetaceans taken from *McArthur* and *Jordan* during PODS93. The numbers indicate the tally of individual photographs taken of each species.

SPECIES	McARTHUR	JORDAN
Delphinus delphis (short)	341	1,028
D. delphis (long)	217	87
Stenella attenuata	159	36
S. attenuata graffmani	10	0
S. coeruleoalba	15	240
S. longirostris	140	0
S. longirostris orientalis	0	13
Steno bredanensis	0	23
Grampus griseus	0	5
Tursiops truncatus	28	16
Lagenorhynchus obliquidens	2	22
Lissodelphis borealis	0	39
Globicephala macrorhynchus	33	73
Pseudorca crassidens	11	0
Orcinus orca	62	61
Berardius bairdii	26	112
Balaenoptera physalus	183	33
B. edeni	0	0
B. borealis	0	17
B. musculus	104	415
Physeter macrocephalus	9	128
Megaptera novaeangliae	16	1,135
TOTAL	1,356	3,483

blue, *Balaenoptera musculus*, and humpback, *Megaptera novaengliae*, whales along the Pacific coast. Table 3 lists the number of approaches, animals, calves, and photo identifications of blue and humpback whales taken from *McArthur* and her rigid-hulled inflatable boat. A total of 68 blue whales were approached to obtain photographs on 48 separate occasions. It is estimated that 57 of these whales were photographed (individually identified). A total of 95 humpback whales were approached on 28 occasions and an estimated 62 animals were photographed for individual identification. An estimated 1,260 photographs of blue and humpback whales were taken during PODS93.

These photographic methods provide a detailed, noninvasive examination of vital population parameters such as survival rates, reproductive rates, calving intervals, and age at first reproduction. Photo identification has proven to be a versatile and powerful technique for addressing a wide variety of management-related issues such as movement, stock identity, and abundance. This year's effort, in conjunction with the ship and aerial surveys, and the genetic inquiries (see below), will allow the SWFSC to make an unprecedented assessment of cetaceans off the coast of Mexico and California. (T. Gerrodette, [619] 546-7131).

Whale Dive Time Studied

Whale dive time studies were initiated this year because of the lack of accurate abundance estimates for certain species (such as sperm and beaked whales) that spend a large amount of time submerged. Available abundance estimates can only be corrected if data on dive times are collected. During the PODS93 survey, 25 animals from 4 different species were monitored. These included 13 Cuvier's beaked whales, *Ziphius cavirostris*; 2 sperm whales, *Physeter macrocephalus*; 6 Blainville's beaked whales, *Mesoplodon densirostris*; and 4 unidentified *Mesoplodon* species. As expected, tracking animals and ensuring that the same group was resighted and that animals were resighted on their first surfacing proved difficult. Additionally, it became clear that dive studies are only likely to be successful under excellent viewing conditions and that high-density areas where one may confuse different groups of animals should be avoided. The data collected during this year's PODS survey represents the beginning of what will hopefully become a larger data base on dive times. (K. Forney, [619] 546-7171)

Undersea Surveillance System Assessed for Providing Data for Whale Population Assessment

A collaborative effort between Southwest Fisheries Science Center and the Naval Oceans System Center was initiated to assess the ability of the

Table 3. The number of approaches, total animals, calves, and photo identifications of blue, *Balaenoptera musculus*, and humpback, *Megaptera novaengliae*, whales from the *McArthur*'s launches during PODS93.

SPECIES	APPROACHES	ANIMALS	CALVES	PHOTO IDs
Balaenoptera musculus	48	68	1	57
Megaptera novaeangliae	28	95	4	62
TOTAL	76	163	5	119

Navy's Integrated Undersea Surveillance System (IUSS) to provide data supporting the assessment of whale populations. This year's acoustic research was focused on whether the IUSS acoustic detection of marine mammals can be correlated with simultaneous visual and acoustic observations from *McArthur*. Also addressed was whether the IUSS-derived information provides the potential for IUSS direction of *McArthur* to locations of high marine mammal activity. Additionally, sonobuoys were deployed from *McArthur* when mysticete whales were sighted in an attempt to obtain baseline vocalizations with positive taxonomic identifications. Signals from the whales were picked up by the sonobuoys and sent to the IUSS. A total of 15 sonobuoys were deployed on blue, fin, humpback, Bryde's, and sei whales. Results of this research will be available by the end of 1994. (K. Forney and J. Rivers, [619] 546-7171)

Dolphin Ecology Studied

Oceanographic data were collected throughout the PODS93 survey. A hull-mounted thermosalinograph was used to collect continuous data on temperature and salinity of surface water. A vertical conductivity-temperature-density (CTD) station was occupied beginning each day 2 hours prior to sunrise and continuing throughout the day at 2-hour intervals. A lighted Secchi disc was lowered into the water to estimate the euphotic zone depth for the morning CTD station. A 12-bottle CTD rosette was used to collect conductivity (salinity), temperature, chlorophyll, C-14 uptake (primary productivity), and nutrient sample data at specific depth intervals. Mini-CTD casts were conducted at 0900, 1200, and 1500 hours each day and at the completion of the survey effort each day with a SEACAT profiler. Expendable bathythermograph (XBT) casts were made if survey effort could not be suspended for a mini-CTD cast. The position and time of each cast was recorded on NOAA XBT and project logs. In Table 4, the environmental data collected during the PODS93 survey aboard *David Starr Jordan* and *McArthur* are summarized. (P. Fiedler, [619] 546-7016)

Table 4. Environmental data (number of samples) collected during PODS93 aboard the NOAA research vessels *David Starr Jordan* and *McArthur* surveying off California and Mexico. CTD = conductivity-temperature-density, XBTs = expendable bathythermographs.

	JORDAN	McARTHUR
CTD casts	63	68
Hydrocasts	9	0
SEACAT	210	227
XBTs	83	52
Chlorophyll-CTD	624	616
Chlorophyll-surface	520	486
C-14 primary productivity	466	469
Nutrient analysis	621	693
Bathythermograph tows	6	0
Lighted nighttime Secci	55	34

Plankton Tows, Dip Net Sampling, and Seabird Observations Conducted

Following the completion of the evening oceanographic sampling, plankton tows were conducted. Surface Manta tows and oblique bongo tows were conducted to collect plankton samples. Lighted dip net sampling was also conducted for approximately one hour at night following the plankton tows. Approximately 385 flying fish of 14 species were caught and frozen for genetic and distributional analyses. A number of small fish were captured in international waters and kept alive for Mexican and U.S. aquarium research and display.

Observations of seabirds were carried out concurrently with marine mammal observations on the flying bridge. During each 2-hour watch, the bird observer would count and identify seabirds viewed in a 90° arc from the bow to either the vessel's port or starboard beam. Observations were made of 13 families, 62 species, and an estimated 14,737 individual seabirds. A total of 141 sea turtles were sighted and 29 were captured and measured. Of these, 27 were tagged and 18 blood samples were collected. All animals were returned to the ocean. (R. Pitman, [619] 546-7173)

Biopsy Tissue Samples Collected for Genetic Analysis

Southwest Fisheries Science Center scientists also collected skin biopsy samples to aid in defining the structure and boundaries of cetacean stocks. Samples were taken from dolphins that approached the vessel to ride the bow wave. A scientist stationed at the bow of the vessel used a crossbow, firing a bolt with a small, hollow tip and then retrieving the line to obtain a tiny piece of tissue from the back of each animal. In general, the procedure did not cause the animals to halt their bow ride. During the PODS93 survey, 41 tissue samples were collected from 5 different species by scientists on board *David Starr Jordan*, and 29 tissue samples were collected from 8 different species by scientists on

board *McArthur*. Table 5 lists the number of samples collected for each species by leg for *David Starr Jordan* and *McArthur* during PODS93 and for *McArthur* during the November-December 1993 Dolphin-Safe Survey.

Table 5. Cetacean biopsy tissue samples for genetic analysis collected aboard the NOAA research vessels *David Starr Jordan* (J-PODS93) and *McArthur* (Mc-PODS93) during PODS93 and aboard *McArthur* (McDS) during the November-December 1993 Dolphin-Safe Survey.

SPECIES	J-PODS 93	Mc-PODS 93	Mc-DS	TOTAL
Lagenorhynchus obliquidens	9	2	0	11
Stenella attenuata	10	3	4	17
S. coeruleoalba	1	0	0	1
S. longirostris	9	3	0	12
Tursiops truncatus	12	6	0	18
Delphinus delphis	0	12	0	12
Steno bredanensis	0	0	1	1
Lissodelphis borealis	0	1	0	1
Balaenoptera musculus	0	1	0	1
Megaptera novaeangliae	0	3	0	3

The tissues will be analyzed for genetic differences using a standard, well-established DNA procedure. Briefly, the procedure first involves extraction of the total cell component of DNA (nuclear and extra-nuclear) from the tissue. The DNA segment desired for analysis (approximately 500 base pairs) is isolated and amplified to high concentrations using the polymerase chain reaction (PCR). This is a rather extraordinary procedure considering that the ratio of desired DNA to the rest of the DNA is less than 1 in 10,000. The amplified segment is analyzed to determine the sequence of nucleotide bases (abbreviated A,C,G, or T) that constitutes the genetic signature of the particular animal. The animals' sequences are then analyzed using computer programs that determine the degree of relatedness between individuals. Besides revealing existence of reproductively isolated populations (stocks) and evolutionary lineages, recently developed methodologies allow estimation of gene flow between lineages and average dispersal distances per generation. (A. Dizon, [619] 546-7089)

Marine Mammal Photogrammetry Activities

Helicopter operations were conducted from *David Starr Jordan* to obtain dolphin school photographs for calibration of observer sightings, cetacean length-frequency analysis, and assessment of pinniped island colonies. Estimates of ceta-

Table 6. Cetacean schools photographed from a helicopter launched from the NOAA research vessel *David Starr Jordan* on PODS93 to calibrate cetacean school size and to conduct length-frequency distribution studies of animals photographed. Values represent the number photographed and the resulting number which proved suitable for calibrating shipboard observer sightings.

SPECIES	NUMBER PHOTO-GRAPHED	CALIBRATIONS
Delphinus delphis	36	19
Stenella attenuata	21	7
S. coeruleoalba	26	7
S. longirostris	6	5
Steno bredanensis	3	1
Tursiops truncatus	24	1
Grampus griseus	17	1
Globicephala macrorhynchus	3	1
Lagenorhynchus obliquidens	2	0
Kogia spp.	4	0
Orcinus orca	2	0
Mesoplodon spp. and *Ziphius* spp.	10	0
Balaenoptera spp.	6	0
B. acutorostrata	1	0
B. edeni	7	0
B. physalus	14	0
B. musculus	3	0
Physeter macrocephalus	5	0
Unidentified cetaceans	3	0
MIXED SCHOOLS		
S. attenuata and *S. longirostris*	5	3
S. attenuata *S. longirostris* and *T. truncatus*	1	1
T. truncatus and *S. coeruleoalba*	1	1
T. truncatus and *G. macrorhynchus*	2	0
T. truncatus & *P. macrocephalus*	1	0
TOTAL	203	47

cean school size made by observers aboard both vessels will be calibrated against counts from aerial photographs. This reveals, and allows correction for, tendencies to over- or underestimate school size, thus providing more accurate estimates of dolphin population size. This year 203 dolphin schools were photographed, and of these, 47 were suitable for school size calibration. Table 6 lists the species photographed, the number of sightings, and the number of photographs which can be used for calibration. Because photographs are taken vertically and with high resolution, lengths of dolphins and whales can be accurately determined. Measurements from the aerial photographs will be used to identify possible differences in average body size among common dolphin stocks. In a cooperative study with Mexican scientists, aerial photographs were taken of California sea lion rookeries along the Pacific coast of Baja California, Mexico. (W. Perryman, [619] 546-7014)

Dolphin-safe Cruise Completed

On December 5, 1993, the Dolphin-Safe Research Project in the eastern tropical Pacific was completed. The NOAA research vessel *McArthur* and the Mexican commercial tuna purse seine *Convemar* embarked upon a combined cooperative research effort directed toward developing a better understanding of the tuna-dolphin associations characteristic of this area. The primary goal of the research program was to collect information that will aid in developing methods of catching large yellowfin tuna in the eastern tropical Pacific Ocean without endangering the dolphins that often occur in association with these fish. The project objectives included the capture, tagging, and simultaneous tracking of spotted dolphins, *Stenella attenuata*, and yellowfin tuna, *Thunnus albacares*. This was a cooperative study conducted by the Inter-American Tropical Tuna Commission (IATTC), NMFS, the University of Hawaii (UH), the Tuna-Dolphin Program (Programa Nacional para el Aprovechamiento del Atún y Protección de los Delfines, or PNAAPD) of Mexico and the National Institute of Fisheries (Instituto Nacional de Pesca, or INP) of Mexico.

Michael Scott from the IATTC was the chief scientist during the cruise. To study the relationship between yellowfin tuna and spotted dolphin, he proposed to simultaneously radio track dolphins and sonic track yellowfin tuna from the same aggregation. Both tuna and dolphin tags were equipped with pressure-sensing devices which would transmit (tuna) or store (dolphin) dive data and permit analyses of their vertical movements. The value of the data collected by this approach is twofold. First, understanding tuna and dolphin movements and interactions in conjunction with food habit studies which are under way at NMFS and IATTC should help to establish the dynamics and duration of the tuna-dolphin bond and the degree to which it is food based. Second, from a management perspective, it may be possible to determine if the bond weakens at particular times, which may make the tuna catchable using dolphin-safe fishing methods.

The 1,200-gross ton, Mexican-flagged tuna purse seine vessel *Convemar* was contracted for 30 days of fishing. The primary function of the *Convemar* was to support the simultaneous tuna-dolphin tracking study by locating, capturing, tagging, and releasing spotted dolphins and yellowfin tuna for subsequent tracking by *McArthur* and its tracking launches. A number of ancillary projects were also completed, including the collection of oceanographic data, seabird identification and estimation, dolphin tissue sampling, dip netting for flying fish, hook-and-line fishing for stomach content analyses, and collection of *Convemar* bycatch data.

Eighteen sets were made on dolphins during the 30-day Dolphin-Safe research cruise. Five spotted dolphins were captured and tagged with radio transmitter packages; all five were successfully tracked. The four radio transmitter packages attached to dolphins tagged and designated as D-7 through D-10 were integrated with time-depth-recorder (TDR) units. The TDRs measured and stored the depth of tagged dolphins every 10 seconds and the ambient sea temperature every minute. One of the tagged dolphins (D-11) was outfitted with a standard radio transmitter package. In order to download data from the TDRs, it was necessary to recapture tagged dolphins and remove the radio tags from the dorsal fins. Three of the four TDR packages were recovered from recaptured dolphins. One of the TDR-tagged dolphins evaded sets on three occasions before it was recaptured on the final set of the trip. This animal will furnish researchers with data on diurnal dive patterns as well as chase behavior. The dive data downloaded from the TDRs ranged from 18 hours to over 4 days in duration.

A total of six yellowfin tuna (T1-T6) were tagged during the research cruise. Three of the tagged tunas (T1, T3, and T5) were tracked successfully. Two of the tagged tunas (T1 and T3) were released simultaneously with the dolphin school during backdown procedure and one tagged tuna (T5) was released after the backdown procedure by releasing the end of the net. Each of the yellowfin tuna that was tracked was outfitted with a 60-KHz sonic

transmitter that broadcasted direction and dive data in real time to the tuna tracking team's tracking equipment. The three tuna tracks were 49, 1, and 8 hours in duration.

The Cruise Report will be available by the end of January. IATTC is expected to submit a final report to NMFS by March 1994. (W. Armstrong, [619] 546-7616)

HONOLULU LABORATORY

Honolulu, Hawaii

Workshop Held on Marine Turtle Hooking Mortality

A Workshop on Marine Turtle Hooking Mortality, sponsored by the Honolulu Laboratory and NMFS Headquarters, was held November 16-18, 1993, in Honolulu. Turtle experts from across the United States, Australia, and Japan participated in this workshop, which was designed to develop a coordinated research plan for estimating the mortality and physiological impact on marine turtles hooked or entangled in longline fishing gear. The first day of the workshop was dedicated to technical presentations on longline fishing, the Endangered Species Act, and turtle physiology and fishery interactions. The second day was a facilitated strategic planning session in which specific research objectives and activities were identified. On the third day, a number of related issues, including mitigation and observer protocol, were discussed, and detailed research outlines were prepared. The results of the workshop will be presented to NMFS Headquarters by January 1, 1994.

Those attending the workshop included Alan Bolten and Elliott Jacobson, University of Florida, Gainesville, Florida; Scott Eckert and Pamela Yochem, Hubbs-Sea World Research Institute, San Diego, California; Kiyoshi Katsuyama, Japan Fishing Agency, Tokyo, Japan; Itaru Uchida, Port of Nagoya Public Aquarium, Minatoku Hagoya City, Japan; Jeffrey Miller, Department of Environment and Heritage, Queensland, Australia; Bernard Thoulag, Micronesian Maritime Authority, Pohnpei, Micronesia; Charles Caillouet, NMFS, Galveston, Texas; Phil Williams, NMFS, Silver Spring, Maryland; Larry Ogren, Southeast Fisheries Science Center (retired); Frederick White, Scripps Institution of Oceanography (retired); and Christofer Boggs and Jerry Wetherall of the Honolulu Laboratory. (G. Balazs, [808] 943-1240; S. Pooley, [808] 943-1241)

Pilot Observer Program Guidelines Developed for Hawaii Longline Fishery

Gerard DiNardo, currently with the Joint Institute for Marine and Atmospheric Research (JIMAR), recently completed the report "Statistical Guidelines for a Pilot Observer Program to Estimate Turtle Takes in the Hawaii Longline Fishery." DiNardo began the project while employed as a fishery biologist at the Honolulu Laboratory. The intent of the report was to provide statistical guidelines for development of an observer sampling program for the Hawaii longline fishery. Development and implementation of the sampling program is a requirement of a recent internal Biological Opinion rendered under a Section 7 Consultation conducted by NMFS in response to concerns regarding the incidental taking of listed sea turtles by this fishery.

The sampling design was developed using 1991 and 1992 Hawaii longline logbook and 1990-92 observer data. The distribution of reported fishing trips by trip type (target species) and associated number of sets fished in the 1991 and 1992 fishing seasons are shown in Table 1. For all months, tuna fishing trips were generally proximal to the Hawaiian Islands with mixed trips north of the tuna effort and swordfish effort north of the mixed effort. Vessels exclusively targeted swordfish, tuna, or some mix of both. During the 1991 fishing season, 28 percent of the longline vessels fished exclusively for tuna, 11 percent fished exclusively for swordfish, and 24 percent always fished for a mixed catch. The remaining vessels (37 percent) switched between targets from trip to trip with no obvious pattern. During the 1992 fishing season, 30 percent of the longline vessels fished exclusively for tuna, 19 percent fished exclusively for swordfish, 31 percent always fished for a mixed catch, and 20 percent switched between targets. The identification of exclusive groups of vessels within the longline fishery is basic to developing strata and sampling frames.

Table 1. Annual number of fishing trips by trip type and associated number of sets fished (in parentheses) from Hawaiian logbook data, 1991-1992.

	Trip Type			
Year	Swordfish	Tuna	Mixed	Total
1991	291	550	824	1,665
	(3,126)	(4,318)	(5,205)	(12,649)
1992	288	468	547	1,303
	(3,531)	(3,868)	(4,121)	(11,520)

A total of 11 trips (109 sets) were monitored by scientific observers in the longline fishery between 1990 and 1992. Because a full-fledged observer program had not been established at the time, cooperating vessels were opportunistically sampled. All vessels monitored fished exclusively for swordfish. A total of 7 turtle interactions were observed on 3 of the 11 monitored trips.

Because information from the Hawaii longline logbook system has not been fully verified by scientific observer reports, the logbook data were assumed to be biased. The reported take of protected species was most likely downwardly biased because of nonreporting. Because the available observer data set was small (11 trips) and limited to vessels fishing exclusively for swordfish, the data were not considered to be representative of turtle interactions in the Hawaii longline fishery.

Consequently, additional baseline turtle interactions data will be required. To collect such data, a stratified pilot sampling design was proposed. Data from the logbooks were used to identify appropriate strata and sampling frames while observer data were used to estimate sample size requirements.

As sources of variability in turtle take rates were not known, stratification was based on characteristics of the fishery. While this approach is not efficient, it represents the best approach until additional data are collected. Two stratification variables were proposed for the pilot survey: time and vessel trip type. In the survey design, all potential vessel trips were classified into unique strata defined by time and trip type. To facilitate sampling, vessel trips within trip type/time strata were defined as the primary sampling units (PSU). A list of PSU belonging to each stratum represents the sampling frame and provides the basis for the selection and identification of the units in the sample. Longline sets within a given vessel trip were defined as the secondary sampling units from which turtle take data will be collected.

For the pilot program, an array of sample size choices was presented to cover a range of tolerance and confidence levels for estimation of total turtle take, assuming both normal and negative binomial take rate distributions. An example of sample size choices, assuming a negative binomial take rate distribution, is presented in Figure 1. It was assumed that approximately 10 longline sets comprise a trip. A sampling frame for the pilot survey

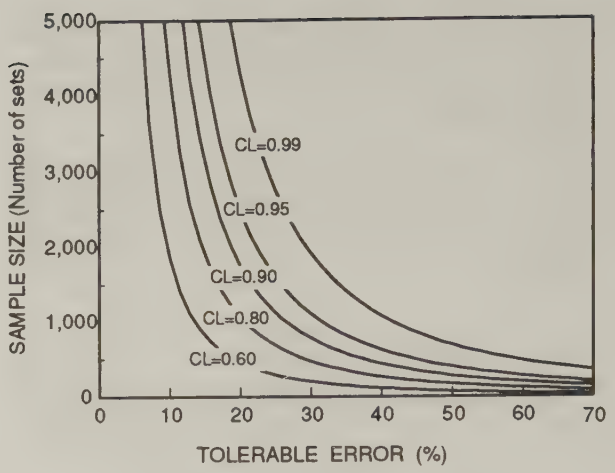

Figure 1. Sample size requirements as a function of percent tolerable error and confidence level (CL) assuming that the distribution of turtle takes conforms to the negative binomial.

was developed and appropriate sample selection procedures advanced. Procedures for optimizing future sampling were also described. (G. DiNardo, [808] 943-1259)

Magnetic Resonance Imaging Used to Examine Brains of Hawaiian Green Turtles

In the Hawaiian Islands, green turtles, *Chelonia mydas*, occur in shallow bays and inshore areas where the algae and sea grasses they favor as food are plentiful. The species is currently listed as threatened under the U.S. Endangered Species Act and is also fully protected under wildlife regulations of the State of Hawaii. NMFS is leading efforts to attempt to restore sea turtles to their former levels of abundance.

A major threat to their recovery has recently appeared in the form of a type of cancer known as cutaneous fibropapilloma, or as fibropapillomatosis. The disease was first discovered in Caribbean green turtles in 1938 and in Hawaiian green turtles in 1958. The incidence of tumors had been rare until the early to mid-1980s, when it increased dramatically and almost simultaneously in Florida and Hawaii. The disease has become particularly acute in the green turtles of Kaneohe Bay (Oahu, Hawaii), the Indian River Lagoon System (Florida), and the Florida Keys, where more than 50 percent of the green turtles now have tumors. The causes and method of spreading the disease are unknown, and both are being actively studied. Parasite eggs and viruses have been observed within the tumors, but their role (if any) in causing the cancer remains unclear. Recent research also suggests that pollutants do not play a major role in the disease.

Tumors most commonly grow in the soft tissue around the neck, head, throat, eyes, and flippers. Turtles with tumors sometimes appear to be lethargic and disoriented, suggesting that the tumors may also affect brain function. If this is indeed true, tumors cause the turtles to be more vulnerable to being attacked by sharks, hit by boats, or entangled in fishing gear. The rationale for this research was to see if turtles with external tumors also show evidence of brain disease.

Robert Lipman and his technical staff at Straub Hospital (Honolulu, Hawaii) graciously agreed to donate their time and expertise to examine turtles with their new Magnetic Resonance Imaging (MRI) unit. This state-of-the-art machine produces highly detailed pictures of internal organs with absolute safety. It therefore allowed detailed evaluation of the brains of tumored and normal turtles but without harm or discomfort to the animals. This work was not intended to produce a cure for the cancers but rather to increase understanding of how the disease affects individual animals and, in turn, how it may be impeding efforts to increase the population of green turtles.

After extensive examination of one heavily tumored and one normal individual, no abnormalities were detected in the tumored animal's brain. Whether tumors are indeed somehow affecting normal brain function in green sea turtles still remains a mystery. Additional studies with Straub Hospital involving MRI of green turtles are being considered. (R. Brill, [808] 943-1234; G. Balazs, [808] 943-1240)

INSULAR RESOURCES INVESTIGATION

Diver-biologists Evaluate Reef Fish Impact on Hawaiian Monk Seals at Midway Atoll

During August 5-19, reef fish abundance and biomass were assessed at Midway Atoll in the Northwestern Hawaiian Islands (NWHI). Honolulu Laboratory Fishery Biologists Edward DeMartini and Frank Parrish, along with Ray Boland of the University of Hawaii, Manoa (UHM), comprised the survey team. The survey, a continuation of work begun at French Frigate Shoals in the summer of 1992, attempted to assess changes in the reef fish assemblage which might impact the forage base of newly weaned Hawaiian monk seals, *Monachus schauinslandii*. The Midway surveys were conducted at the same locations as fish surveys of the early 1980s, completed by the Hawaii Cooperative Fishery Research Unit of the UHM. Eight of nine historical stations in three major habitats (outside barrier reef, inside barrier reef, and lagoonal patch reefs) were successfully resampled. Preliminary results show consistently greater fish densities at the patch reefs than at the barrier reef stations. This phenomenon was noted previously for shallow reef fishes at French Frigate Shoals. Also, fish densities were similar at the historical test stations and at the newly sampled reference stations on the 1993 survey.

The diver-biologists also collected approximately 200 specimens of two species of reef fish from three other sites within each of the three major habitats. The fish collected, the wrasse, *Thalassoma ballieui*, and the surgeonfish, *Ctenochaetus strigosus*, were divided into three specific size classes. These specimens were sent to the NMFS Charleston Laboratory for accurate analyses of ciguatera toxin (CTX). The design should allow a novel evaluation of the effects of body size within fish species and the effects of reef site within habitat type on the incidence of CTX in potential reef fish prey. (E. DeMartini, [808] 943-1266; F. Parrish, [808] 943-1254)

Northwestern Hawaiian Island Sexually Mature Spiny Lobster Decline in Size

The Northwestern Hawaiian Island (NWHI) spiny lobster, *Panulirus marginatus*, population has substantially declined since research cruises first documented the resource in the mid-1970s. To determine if the reproductive potential of the population at two separate NWHI commercial lobster fishing sites (Necker Island and Maro Reef) changed in response to reduced density, a hyperbolic tangent function (TANH) was fit to the proportion of females with eggs in each 1-mm size class. The TANH function was fit to three periods: 1977-79, 1985-88, and 1990-93. Spiny lobster research was conducted at these two NWHI sites for each of the three periods. Comparisons are between time periods, not necessarily between sites. The first period represents light exploitation and high population levels; the second, a period of heavy exploitation and a fishing down of the population; and during the last period, population numbers declined and density was much less than during the first two periods. At Necker Island, the size at onset of egg production dropped significantly from 1977-79 to 1985-88 and again from 1985-88 to 1990-93. At Maro Reef, the size at onset of egg production was not statistically different between the first two periods but dropped significantly during 1990-93 (Table 2). Preliminary research on genotypic variation in the NWHI spiny lobster population indicated that fishing pressure, which may induce a genetic selection pressure for lobster with a smaller size at maturity, was not a probable

Table 2. Length at onset of egg production of the Northwestern Hawaiian Island spiny lobster for 1977-79, 1985-88, and 1990-93 at Necker Island and Maro Reef. Comparisons are between periods, not necessarily between sites. CL = carapace length (mm). Standard error (SE) in parentheses. *N* denotes sample size.

Location	1977-79			1985-88			1990-93		
	N	CL	(SE)	*N*	CL	(SE)	*N*	CL	(SE)
Necker Island	2,545	65.5	(0.8)	1,568	60.4	(0.9)	2,939	50.7	(0.4)
Maro Reef	1,534	69.4	(1.4)	2,818	69.1	(1.8)	499	51.3	(2.7)

cause for the size change. Therefore, it is most likely that the change in size at sexual maturity reflects density-dependent biological response by the population to declining lobster densities in the NWHI. (W. Haight, [808] 943-1236)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Social Science Investigators Meet

Social science investigators from the University of Hawaii's Pelagic Fisheries Research Program (PFRP) met at the Honolulu Laboratory on November 5, 1993, to discuss issues of project coordination. Thirteen people, including PFRP Program Manager John Sibert, attended the meeting. Suggestions were made for sharing data acquisition, but no specific conclusions were reached. Investigators were encouraged to attend the May 1994 tuna conference in California.

Fishery Management and Performance Investigation Leader Sam Pooley calculated revised estimates of 1992 commercial landings for Hawaii. Combining State of Hawaii commercial catch reports with NMFS logbook and shoreside monitoring information, total commercial landings in 1992 were 30.4 million pounds ($62 million). Longline landings accounted for 21.2 million pounds ($44.6 million) of this total; the small-scale troll-handline pelagics fishery was the second largest fishery (4.4 million pounds, $7.2 million). Landings in 1991 were approximately 29 million pounds ($61 million). The 1992 information will be included in next year's *Fisheries of the United States*. (S. Pooley, [808] 943-1216)

United Nations Moratorium Report Completed

Fishery Management and Performance Investigation Chief Sam Pooley reported that Daniel D. Huppert and Todd Mittleman of the University of Washington completed their report "Economic Effects of the United Nations Moratorium on High Seas Driftnet Fishing" in September 1993. The report was the result of a research grant supported by the NMFS Southwest Fisheries Science Center and is being issued as a NOAA Technical Memorandum.

This report concentrates on the likely disposition of the Asian driftnet fleet following the imposition of the moratorium in 1992. Table 3 indicates the projected disposition based on field work in Japan, South Korea, and Taiwan in late 1992. The basic alternative dispositions were to scrap it or shift it into alternative fisheries. The authors found that government compensation programs were important in scrapping vessels, with a much higher percentage of vessels being scrapped in Japan because of a well-financed compensation program. Restrictions and opportunities in alternative fisheries also differed among the countries, as did the relative costs and capabilities of the vessels.

Table 3. Projected disposition of the Asian base driftnet fleet (from Huppert and Mittleman 1993).

	Country		
Disposition	Japan	Korea	Taiwan
Number vessels in 1991	454	142	223
Number vessels planned for scrap	280	30	60
Number vessels estimated for scrap	98	-	-
Number vessels switching to squid jigging	26	90	55
Number vessels switching to tuna longline and pole-and-line	32	-	90
Number vessels switching to trawl and bottom longline	18	-	18
Number vessels switching to saury dipnet	-	22	-
Total number vessels switching to alternative fisheries	76	112	163

Huppert and Mittleman found that the overall economic impact of the high-seas driftnet moratorium on the three countries was not easily summarized nor were the potential impacts on other countries through conversion into other fisheries or through reductions in landings of squid and albacore. However, the authors estimated that 8,000 of the 16,000 people employed by the driftnet fishing industry lost their jobs because of the moratorium and that the total value of lost seafood landings is $414 million. The purpose of the driftnet moratorium was to support the populations of high-seas marine mammals, birds, and turtles.

Huppert is associate professor of economics at the University of Washington's School of Marine Affairs. Mittleman was a graduate student and associate investigator on the project. (S. Pooley, [808] 943-1216)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

MATHEMATICAL MODELING AND DATA ANALYSIS

CEOS Program Studies Potential Effects of Global Climate Change

The Fisheries Climatology task at the Pacific Fisheries Environmental Group (PFEG) has been putting significant effort into the Climate and Eastern Ocean Systems (CEOS) Program, an international collaborative study of potential effects of global climate change on the living resources of the highly productive eastern ocean upwelling ecosystems and on the ecological and economic issues directly associated with such effects. A major focus of the program is the clupeoid fishes (anchovies, sardines) that are heavily exploited in these large marine ecosystems. The clupeoid fishes have been exhibiting episodes of collapse, rebound, or switches in dominance, often in what appears to be synchronicity across ecosystems.

The CEOS Program started as an effort between the U.S./NOAA/NMFS Pacific Fisheries Environmental Group, the French Terre Ocean Atmosphere Department of the Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM), and the Philippine International Center for Living Aquatic Resources Management (ICLARM). NOAA funding is from the Southwest Fisheries Science Center/PFEG and the Marine Ecosystem Response program of the Office of Global Programs. French funding comes from the DURR (Dynamics and Use of Renewable Resources) Initiative Program of ORSTOM. Since its inception, the CEOS program has grown into a cooperative network of over 40 scientists from more than 15 countries, many of whom have visited PFEG for collaborative work for short periods. The principal CEOS scientists in the United States are Operations Research Analyst Roy Mendelssohn, PFEG Fishery Biologist Richard Parrish, and PFEG Oceanographer David Husby. Former PFEG Chief Andrew Bakun, presently at the United Nations Food and Agriculture Organization (FAO), also remains involved in CEOS. Two visiting scientists from ORSTOM, Phillippe Cury and Claude Roy, are nearing the end of a 3-year stay at PFEG. An additional French contribution includes socioeconomic research by Marie Helene Durand of ORSTOM Paris.

The major objectives of the CEOS Program are to (1) assemble, summarize, and analyze the long-term data record of the four major eastern ocean boundary upwelling ecosystems along with data from other relevant upwelling regions; (2) apply the comparative method to identify key physical processes and ecosystem responses; (3) resolve underlying global-scale trends in each individual ecosystem that may be obscured by local interyear and interdecadal variability; (4) investigate the relationship of these global trends to accumulating greenhouse effects and other possible causes of climate change; (5) construct scenarios for future consequences of global climate change on upwelling resources; and (6) analyze and project ecological, economic, and social impacts on associated human activities.

Eastern ocean upwelling ecosystems present certain advantages that may make the study of climate change on marine ecosystems particularly tractable: these include the similarity of the major fish species and of their trophic structures and dynamics, the similarity of the major ocean processes affecting these ecosystems, and the many years of data available. Thus, the study may serve an even wider purpose as an illustration of the sorts of impacts that could affect more complex marine ecosystems. This work follows up on the comparative ecosystem approach developed at PFEG.

Work is under way on several aspects of CEOS research, and papers on the program have recently

been presented at the Pacific International Council for Exploration of the Sea meeting, the American Geophysical Union/American Society of Limnology and Oceanography Ocean Science meeting, and at an FAO meeting in Rome on small pelagics. (R. Mendelssohn, [408] 656-3311)

PHYSICAL OCEANOGRAPHY PROGRAM

Joint NMFS-National Ocean Service Research Describes Midlatitude Connection to Tropical El Niño Events

An important topic of discussion at the 1958 Rancho Santa Fe Symposium, which was convened to discuss the extreme 1957-1958 California Current El Niño warming, was the nature of the physical connections between the tropical and California El Niño. Since then, many observational and theoretical studies have shown that both oceanic and atmospheric processes are important in bringing warming conditions from the tropical ocean to the California Current region. However, none of these studies have shown methods for distinguishing unique effects associated with either oceanic or regional atmospheric processes.

In a recent study, Pacific Fisheries Environmental Group Oceanographer Jerry Norton and Doug McLain of the Ocean Applications Branch of the National Ocean Service have found ways to distinguish between large-scale warming and cooling effects brought on by the regional atmosphere (forced by a tropical to midlatitude teleconnection) and those apparently brought on by ocean processes. Norton and McLain examined surface and subsurface data from a large west coast area represented in the U.S. Navy Master Oceanographic Observation Data Set and found that the El Niño oceanic signal was evident throughout the ocean's top 300 meters. The data covered an area bounded by the west coast of the United States, from San Diego, California, to Vancouver, Canada, extending seaward 200 miles.

Correlations between fall-winter subsurface temperature and the atmospheric index time series suggest that coherent ocean temperature changes extending from the surface to a 300-meter depth indicate remote forcing from the equatorial atmosphere through the ocean. Correlations between time series of ocean temperature change and series of equatorial sea level pressure change at 12.4° S x 130.9° E were as large ($r > 0.6$) below 100 meters as at the surface. Vertically coherent warming events occurred only during moderate-to-strong El Niño years. The inference is that changes in the Equatorial Pacific atmosphere excite long, internal oceanic Kelvin waves which travel to the eastern Pacific border and then poleward to higher latitudes where this influx of energy favors downwelling and warming. Ocean events associated with regional North Pacific sea level atmospheric pressure change at 45° N x 165° W, and direct atmospheric forcing have correlations that are greatest in the upper 50 meters of the ocean. In general, changes in ocean temperature below a 100-meter depth are not significantly correlated with North Pacific sea level pressure changes.

These results are illustrated in Table 1, in which correlation values for the surface and for a 200-meter depth are shown. A higher correlation coefficient, r, indicates a closer numerical relationship between the series compared. When the equatorial atmospheric index increases, the coastal ocean is warmer, as shown by the positive r values. When the North Pacific index increases, the coastal ocean is cooler. This inverse relationship is shown by the negative values in Table 1. Correlation of temperature change in the large coastal study area with the

Table 1. Correlation between atmospheric forcing indices and ocean temperature change values for the fall-winter period in an area bounded by the west coast of the United States, from San Diego, California, to Vancouver, Canada, extending seaward 200 miles. The first column (left) gives the location of the indices of atmospheric pressure change: Equatorial Pacific and North Pacific. Depths in meters (m) are given at the top. Each entry has two values separated by a comma. The first value is the correlation coefficient and the second is the number of months elapsed before the maximum correlation occurred. For $|r| \geq 0.40$, significance levels are greater than 0.05.

Correlation of atmosphere and ocean temperature indices		
Atmospheric Index	Correlation (r) and atmospheric leads/lags (+/-) in months	
	0 m	200 m
Equatorial Pacific (12.4° S x 130.9° E)	0.65, +6	0.72, +6
North Pacific (45° N x 165° W)	-0.61, 0	-0.20, 0

equatorial atmosphere is as great at 200 meters as at the surface (Table 1, top row). Correlation with North Pacific direct atmospheric forcing is clearly greater at 0 meters than at 200 meters (Table 1).

A higher correlation coefficient, *r*, indicates a closer numerical relationship between the series compared.

The lag (number following comma in Table 1) shown by the top two values of Table 1 provides an additional distinction between the regional atmospheric and remote oceanic-induced changes in the coastal ocean. Positive 6-month lags in the top row suggests that the signal related to equatorial forcing takes up to 6 months to become fully developed in the large coastal study area. A paper describing this research was recently accepted for publication in the Journal of Geophysical Research, Oceans. (J. Norton, [408] 656-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

13th North Pacific Albacore Workshop Held

The 13th North Pacific Albacore Workshop was conducted at the Southwest Fisheries Science Center in La Jolla during the period December 8-14, 1993. Workshop participants from Japan, Korea, Mexico, Taiwan, and the United States reviewed 30 working documents and concluded the following:

The catch-per-unit effort (CPUE) indices for young albacore has declined by 50-70 percent since the mid-1970s. CPUE for adult fish has been stable or slightly declining since 1972. Fisheries data used in a nonequilibrium production model analysis (ASPIC) produced a maximum sustainable yield (MSY) of 71,800 metric tons (t), 80 percent confidence limits: 67,700 to 79,500 t for the North Pacific stock. This latest MSY estimate is consistent with earlier estimates produced by the workshop.

The analysis also indicated that the biomass of the stock dropped below that needed to support MSY in 1974 and continued to decline until about 1990, reaching a level of about 40 percent of MSY biomass. With significant reduction in fishing effort since 1990, largely due to suspension of the driftnet fishery, stock biomass apparently began increasing. If this reduced fishing continues and annual catches remain at the 30,000 t level (average of the last 5 years excluding the driftnet catches), the biomass should continue to increase and reach the level needed to support MSY catches in 5 years. If catches, however, increase to an annual level of 50,000 t, the recovery time will be more than 10 years. Further research to verify these findings was identified by the participants, and a plan for verifying the results and for understanding the population recovery process was developed. The next workshop is tentatively scheduled for April 1995. (N. Bartoo, [619] 546-7073)

U.S. North Pacific Albacore Fishery Reviewed, 1991-1993

Dave Holts, fishery biologist, and Al Coan, mathematical statistician, presented a paper at the Albacore Workshop that was titled "Review of the U.S. North Pacific Troll Fishery for 1991-1993." High points of the paper are as follows:

The U. S. albacore troll fleet consists mainly of vessels operating out of Hawaii and the west coast States. The number of vessels fishing for albacore varies tremendously from year to year. Many troll vessels fish for albacore exclusively--in the South Pacific in the winter and in the North Pacific in the summer and fall. Other vessels only fish for albacore seasonally in the North Pacific and switch gears to participate in alternate fisheries.

Since the development of the South Pacific albacore fishery, a number of vessels return to Hawaii in April and May to reprovision for the North Pacific season. This allows them the opportunity for an early start in the mid-North Pacific while vessels departing from the west coast usually begin fishing in June and July.

Total catches from 1977 through 1992 averaged 6,300 metric tons (t), but had not exceeded 5,000 t since 1985. Catch for 1991 was the lowest on record at 1,828 t while the 1992 catch increased to 4,572 t and the 1993 season catches increased to at least 5,800 t. Albacore delivered to Terminal Island, California, were sold for $1,950 to $2,100 per metric ton. Albacore less than 4 kilograms (kg) were valued at only $1,480 per t.

Table 1. U.S. North Pacific troll fishery catch, effort, and coverage data for 1990 to 1993. t = metric tons, CPE F/D = average number of albacore caught per day fishing.

YEAR	CATCH t	CPE F/D	DAYS FISHING	COVERAGE RATES	AVERAGE SIZE	
					CM	KG
1990	2,818	36	10,437	57%	71.0	7.4
1991	1,845	36	8,900	62%	65.1	5.7
1992	4,572	54	15,800	38%	63.7	5.4
1993	5,800	35	20,236	13%	69.5	7.0

1993 data are preliminary

Areas of greatest annual catch changes depended on various environmental factors, including sea surface temperatures, strength of boundary features in the North Pacific Transition Zone, development of frontal structures, upwelling or the occurrence of an El Niño and related events. Highest catch rates in 1991 occurred in August, 900 to 1,300 nautical miles (nmi) off southern Oregon. Catches in 1992 were highest in August and occurred within 200 nmi of the Oregon-Washington coastline where a strong surface front had developed along the 15°C isotherm.

In 1993, most of the fleet moved from the mid-Pacific eastward to more coastal areas as the season progressed. The 1993 season was marked by a lack of good frontal development which may have limited formation of large concentrations of albacore, although fair catches were made into late October and early November when the fishery ended off northern California.

Annual CPE estimates (average number of albacore caught per day fishing [F/D], by 1° square) were 36 F/D in 1991, 54 F/D in 1992, and 35 F/D in 1993. These values are typical of those recorded over the past decade.

The range of variation in sizes of albacore observed in recent years is similar to ranges reported in historical data. Total troll-caught albacore measured by port samplers and onboard biologists totaled 24,000 in 1991, 41,000 in 1992, and 11,000 in 1993. Average overall length recorded was 65.1 centimeters (cm; 5.7 kg) in 1991, 63.7 cm (5.4 kg) in 1992 (lowest reported since 1955), and 69.5 cm (7.0 kg) in 1993. Four-year-old albacore comparable to those recorded in 1990, 1991, and 1993 catches were nearly absent in the 1992 landings. (D. Holts, [619] 546-7186; A. Coan, [619] 546-7079)

North Pacific Albacore Spawning Seasonality Studied

Darlene Ramon presented a paper at the Albacore Workshop on the spawning seasonality of albacore, *Thunnus alalunga*, in the North Pacific. In the paper, she gave the results of a study she has made of albacore sampled aboard a U.S. troll vessel during the summer of 1990 in the North Pacific Transition Zone (NPTZ) and of another group of albacore caught near the Hawaiian Islands by U.S. longline vessels during the period 1991-1993.

The samples from the NPTZ were collected on board the troll vessel *Pursuit* by NMFS observer John Childers. The *Pursuit* is one of those troll vessels which heads and guts fish prior to landing, as opposed to landing the fish whole. The samples, from three size groups of albacore 70-79 centimeters (cm), 80-89 cm, and 90+ cm in length were collected so that maturity and sex ratio could be determined. A total of 74 albacore gonads were collected during the 1990 fishing season, of which 63 were taken from females and 11 from males. The ovary samples from Hawaii were collected during 1990-1991 from Honolulu fish markets by Biological Technician Don Hawn of Southwest Fisheries Science Center's Honolulu Laboratory. The samples were taken from 96 large female albacore greater than 90 cm in length.

To determine maturity for female albacore, Ramon calculated the gonosomatic index, measured oocyte diameter, and examined ovaries for residual oocytes. The oocyte diameters were measured from the most advanced mode of oocytes within the ovary. The condition of albacore caught in the NPTZ was categorized as reproductively inactive, with the largest oocyte mode being <0.25 millimeters (mm). Hawaiian-caught albacore were large (> 90 cm) and ranged in development from inactive to mature. Hawaiian oocyte diameter increased significantly

during April and maintained an advanced mode size of >0.5 mm through August. Oocyte diameters in the range of 0.7 to 0.8 mm were found in the ovaries of oocytes in the migratory nucleus stage. However, because of the time between capture and sampling, histology was inconclusive on the presence of post-ovulatory follicles. Instead, residual oocytes were used as indicators of previous recent spawning. The residual oocytes were found in many ovaries collected during the summer but were absent in samples collected from September through March.

From the study, it appears that spawning activity near Hawaii occurs between April and August based on the criteria used to determine maturity. (D. Ramon, [619] 546-7074)

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

North Pacific Albacore Fishery Data Reviewed

Al Coan, mathematical statistician, presented a paper titled "Available fisheries data from albacore fisheries in the North Pacific," at the 13th North Pacific Albacore Workshop. Available catch, catch and effort, and length-frequency data for albacore fisheries operating in the North Pacific were presented.

Catch data by fishing gear were listed for the period 1952-1992 for Japan, Taiwan, Korea, the United States, and Canada. Catches peaked in 1976 at 124,000 metric tons (t) and declined to a low of 36,000 t in 1991. The majority of the catch was made by Japan using pole-and-line, longline, gillnet, and purse seine fishing gear.

Catch-and-effort data were available for Taiwan longline (1967-1991), Japan longline (1952-1991), Japan pole-and-line (1956-1991), Korea longline (1966-1970, 1975-1987), and U.S. pole-and-line and troll (1961-1992). The majority of the longline data were by month and 5° square, and the pole-and-line and troll data were by month and 1° square.

Albacore length-frequency data were available for Japan longline and pole-and-line (1956-1991) and U.S. pole-and-line and troll (1961-1992). The majority of the Japanese data were by quarter and 5° x 10° square, and the U.S. data were by month and 1° square. (A. Coan, [619] 546-7079)

TIBURON LABORATORY

Tiburon, California

GROUNDFISH ANALYSIS AND GROUNDFISH COMMUNITIES INVESTIGATIONS

Offshore Trawl Surveys and Nearshore Direct Observations Compared to Estimate Year-class Strength of Blue and Yellowtail Rockfish

Large interannual fluctuations in reproductive success are characteristic of many stocks of rockfish, *Sebastes* spp., along the central California coast. Developing an understanding of the causes of variable year-class strength has been a topic of major interest to researchers at the Tiburon Laboratory over the last decade. For example, indices of year-class

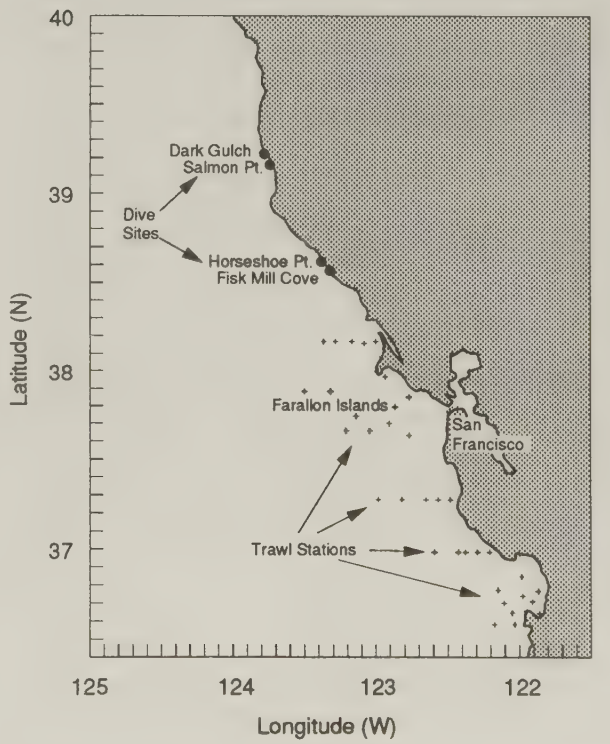

Figure 1. Map of the Groundfish Analysis Investigation (GAI) midwater trawl (+) stations and Groundfish Communities Investigation (GCI) underwater observation survey areas off California, 1983-1992. GAI survey area is from Monterey Bay to Point Reyes; GCI area is at Horseshoe Pt./Fisk Mill Cove and Dark Gulch/Salmon Pt.

strength have been calculated by Groundfish Analysis Investigation (GAI) scientists who have sampled pelagic young-of-the-year juveniles from Monterey Bay to Point Reyes every year since 1983 with a midwater trawl. Likewise, investigators in the Groundfish Communities Investigation (GCI) have censused the relative abundance of settled young-of-the-year juveniles by direct underwater observation at four sites along the California coast: Horseshoe Point/Fisk Mill Cove in Sonoma County and Dark Gulch/Salmon Point in Mendocino County during the same years (Fig. 1). Midwater trawl statistics have been gathered at the time of maximum pelagic juvenile availability (May-June), whereas underwater observations have been conducted in August and September immediately following the period of peak settlement.

The two data sets were recently compared by Steve Ralston (GAI) and Dan Howard (GCI) to examine the similarity of abundance trends of blue rockfish, Sebastes mystinus, and yellowtail rockfish, Sebastes flavidus, the two species that are sampled in common by the two relative abundance surveys. Despite what might be considered substantial spatial and temporal separation in where and when the data were collected, there are good correlations among the trawl and underwater survey data (Fig. 2). As might be expected, the midwater trawl data were somewhat better correlated with the Horseshoe Pt./Fisk Mill Cove data than with the Dark Gulch/Salmon Pt. data. Even so, in all cases, correlations were significant at the $P = 0.01$ level.

Possible links between fluctuations in young-of-the-year juvenile abundance and interannual differences in the ocean environment were examined. Due to the substantial correlations among the various abundance time series (midwater trawl, Monterey Bay to Pt. Reyes and underwater surveys, Horseshoe Pt./Fisk Mill Cove and Dark Gulch/Salmon Pt.), the data for each of the two species can be condensed using the multivariate technique of principal component analysis. Then, when the first component abundance scores are plotted against an index of sea surface temperature (SST °C), a dome-shaped relationship is revealed (Fig. 3). Warm years, like the 1983 and 1992 El Niños, seem to result in low abundances of both blue and yellowtail rockfish. Similarly, cold years (that is, 1989 and 1990) have been characterized by reduced levels of abundance. Intermediate values of SST, however, were associated with years where

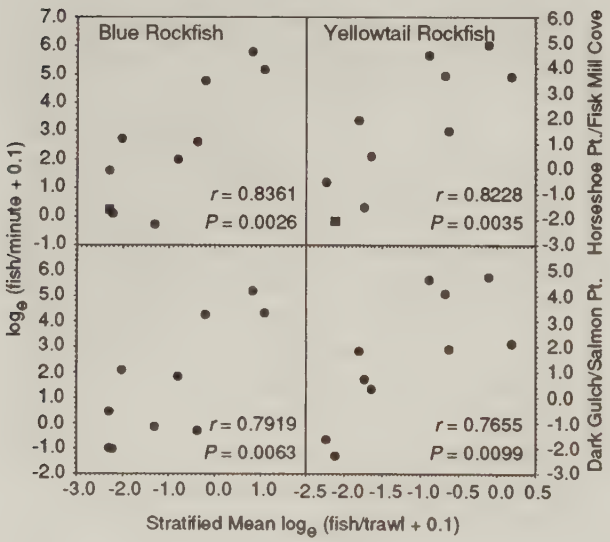

Figure 2. Scattergrams of direct underwater observational data (ordinate), collected at Horseshoe Pt./Fisk Mill Cove and at Dark Gulch/Salmon Pt. off the coast of California, on midwater trawl survey data (abscissa) collected from Monterey Bay to Point Reyes, California, for young-of-the-year juvenile blue and yellowtail rockfishes.

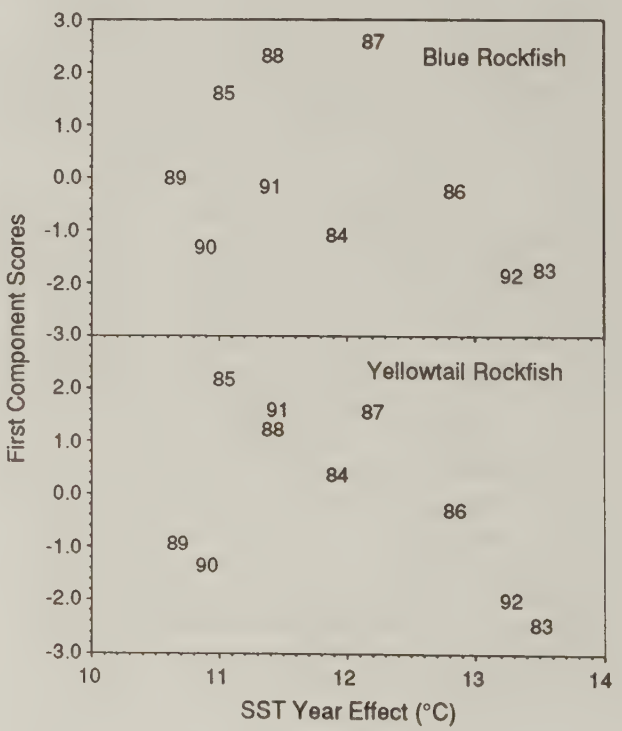

Figure 3. Relationship between young-of-the-year juvenile blue and yellowtail rockfish abundance and sea surface temperature (SST). Data collected along the California coastline at Horseshoe Pt./Fisk Mill Cove and Dark Gulch/Salmon Pt. and from Monterey Bay to Point Reyes, California, 1983-1992.

the young-of-the-year rockfish juveniles were most abundant (for example, 1987 and 1988). (S. Ralston and D. Howard, [415] 435-3149)

INFORMATION TECHNOLOGY SERVICES

IT-95 System Execution Phase Begins

The Information Technology - 1995 (IT-95) systems contract, awarded to Control Data in May 1993, was modified to upgrade the proposed 32-bit Silicon Graphics system to the 64-bit processors and the proprietary communication products to the 3COM router/hub/communications components. The modified contract is to provide the Silicon Graphics (SGI) Challenge L for the host systems and the SGI Indigo for the scientific workstations. With the acceptance by NMFS of the contract modifications in September, the first phase of the execution plan commenced.

With FY 1993 IT-95 funds, three host systems were ordered and delivered to the mandatory sites: Alaska Fisheries Science Center (AFSC), Seattle, Washington; Southeast Fisheries Science Center, Miami, Florida; and Statistics Division, NMFS Headquarters, Silver Spring, Maryland. These systems have been installed and are being implemented for the transition from their current computing environment to the IT-95 platforms. According to the NMFS overseer on the IT-95 project, Manager Michael Fraser, there are FY 94 funds available to procure the host systems for four of the six remaining optional sites: Southwest Fisheries Science Center (SWFSC), La Jolla, California, and Honolulu, Hawaii; Northeast Fisheries Science Center, Woods Hole, Massachusetts; and Alaska Fisheries Science Center, Auke Bay, Alaska. FY 1994 deliveries to the La Jolla and Honolulu sites will depend on available funding to cover their management/maintenance resources. The purchase of the host systems for the two other optional sites (Northwest Fisheries Science Center in Seattle, Washington, and SWFSC in Monterey, California) is targeted for FY 1995.

In addition to the three host systems, each of the IT-95 sites and the regional offices received an SGI INDIGO graphical workstation as a training tool for its staff. This should allow the NMFS-wide staff to go through the learning curve at the same time. The FY 1993 IT-95 funds covered the baseline configuration of the hardware and software for these graphical workstations to meet training purposes. Beyond the warranty period of these delivered workstations, each site must fund its system's hardware/software maintenance fees. Optional components to meet a site's additional requirements could be purchased under the IT-95 contract with the site's own project funds.

The SGI INDIGO (R4000) workstations for the three Southwest regional sites were delivered in mid-December to Long Beach, Honolulu, and La Jolla. The basic hardware components for these systems are desktop workstation, CD ROM drive, 1-gigabyte (Gb) system disk, 1-Gb disk add-on, 1-Gb 1/4-inch (in) tape drive, 5-Gb 8-millimeter tape drive, 16-in monitor, 32-megabyte (Mb) memory upgrade, and 32-Mb memory add-on. The software components are an IRIX workstation operating system, IRIX Developer's Option, back-up utility EL*AWBUS, ORACLE V7 with TPO, SQL*Net, ORACLE TCP/IP, SQL*FORMS, SQL*REPORT WRITER, SQL*PLUS, SQL*MENU, DOCUMENTER'S WORKBENCH, PRO*C, PRO*FORTRAN, FORTRAN 77-UNIX, and GRAL PHIGS. GRAL PHIGS is a graphics library routine for generating selected standard graphics output.

The La Jolla SGI workstation is located in the Information Technology Services (ITS) office area and is linked to the LAN. It will be administered by the ITS staff for access by La Jolla users. This workstation, configured with FORTRAN, C and GRAL PHIGS, will be a scientific applications server. ITS will provide users with assistance in the development/conversion of software applications and the development of relational data bases under the IRIX operating system environment. With an operating system identical to the IT-95 host, applications developed on the SGI workstation are executable on the IT-95 host without modifications. Coupled with the SUN ORACLE data base server, the SGI server provides the IT-95 hardware and software training resources for the La Jolla staff. (D. Roll, [619] 546-7057)

PUBLICATIONS

Published

This published list encompasses publications for the year 1993 for the Southwest Fisheries Science Center, as of press time (January 1994). Abstracts are provided for those publications being listed for

the first time (not listed in previous 1993 Reports of Activities).

Adams, P. B., S. Ralston, and T. E. Laidig. 1993. Occurrence of an exceptional catch of pelagic juvenile lingcod (*Ophiodon elongatus*) off Point Reyes, California. Fish. Oceanogr. 2(2):97-100.

Ainley, D. G., W. J. Sydeman, R. H. Parrish, and W. H. Lenarz. 1993. Oceanic factors influencing distribution of young rockfish (*Sebastes*) in central California: A predator's perspective. Calif. Coop. Oceanic Fish. Invest. Rep. 34:133-140.

The diet of a seabird, the Common Murre, *Uria aalge*, was used to assess the abundance of juvenile rockfish (*Sebastes* spp., mostly *S. jordani*) in the Gulf of the Farallones, California, 1973-90. On the basis of an exploratory analysis of the data and of several oceanographic factors, the researchers hypothesized that availability of fish in the study area during June-July was a function of advection during the January-February period of rockfish parturition. When upwelling or downwelling was persistent in winter, there were few juveniles in late spring, but when upwelling had been mild or pulsed, juveniles were abundant. Rockfish availability also decreased when turbulence, sea level, and sea surface temperature were high during winter. Stepwise multiple regression analyses indicated that, among these variables, advective transport significantly affects the distribution of juvenile rockfish.

Alauddin, M., D. Squires, and C. Tisdell. 1993. Divergency between average and frontier production technologies: an empirical investigation for Bangladesh. Appl. Econ. 25:379-388.

Atkinson, S., W. G. Gilmartin, and B. L. Lasley. 1993. Testosterone response to a gonadotrophin-releasing hormone agonist in Hawaiian monk seals (*Monachus schauinslandi*). J. Reprod. Fert. 97:35-38.

Bailey, K. M., R. D. Brodeur, N. Merati, and M. M. Yoklavich. 1993. Predation on walleye pollock, *Theragra chalcogramma*, eggs and yolk-sac larvae by pelagic crustacean invertebrates in the western Gulf of Alaska. Fish. Oceanogr. 2(1):30-39.

Balazs, G. H. 1993. Annotated list of shark attacks in the Hawaiian Islands, 1779-1993. Appendix A. *In* Borg, J., Tigers of the sea: Hawaii's deadly sharks, p. 63-83. Mutual Publishing, Honolulu, HI.

Balazs, G. H., R. Fujioka, and C. Fujioka. 1993. Marine turtle faeces on Hawaiian beaches. Mar. Pollut. Bull 26:392-394.

Barlow, J., L. Fleischer, K. A. Forney, O. Maravilla-Chavez. 1993. An experimental aerial survey for vaquita, *Phocoena sinus*, in the northern Gulf of California, Mexico. Marine Mammal Science 9(1):89-94.

Bartoo, N., and D. Holts. 1993. Estimated drift gillnet selectivity for albacore, *Thunnus alalunga*. Fish. Bull., U.S. 91(2):371-378.

Bartoo, N., D. Holts, and C. Brown. 1993. Evidence of interactions between high seas driftnet fisheries and the North American troll fishery for albacore. Bulletin 53 (II)—North Pacific Commission 53:367-380.

During the 1990 North American albacore troll fishery, observers aboard United States troll vessels examined 19,526 albacore for evidence of driftnet damage. Results indicate that 13.4 percent of the albacore caught had encountered driftnets. Proportions varied by area fished.

Bence, J. R., A. Gordoa, and J. E. Hightower. 1993. The influence of age-selective surveys on the reliability of stock synthesis assessments. Can. J. Fish. Aquat. Sci. 50(4):827-840.

Bigelow, K. A., and K. C. Landgraf. 1993. Hatch dates and growth of *Ommastrephes bartramii* paralarvae from Hawaiian waters as determined from statolith analysis. *In* Okutani, T., R. K. O'Dor, and T. Kubodera (eds.), Recent advances in cephalopod fisheries biology, p. 15-24. Tokai University Press, Tokyo.

Brill, R. W., and D. B. Holts. 1993. Effects of entanglement and escape from high-seas driftnets on rates of natural mortality of North Pacific albacore, *Thunnus alalunga*. Fish. Bull., U.S. 91(4):798-803.

Carretta, J. V., and K. A. Forney. 1993. Report of the aerial surveys for marine mammals in California coastal waters utilizing a NOAA DeHavilland Twin Otter Aircraft March 9-April 7, 1991, February 8-April 6, 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-185, 92 p.

Due to results of the incidental take of cetaceans in drift and gillnets along the California coast and the need to determine the impact of this mortality on cetacean populations, two aerial surveys were conducted by Southwest Fisheries Science Center from March 9 to April 7, 1991, and from February 8 to April 6, 1992, in coastal waters off California. The objectives of the surveys were to (1) obtain winter abundance estimates for cetacean species commonly found in coastal California waters, (2) establish a baseline for detecting seasonal and interannual changes in marine mammal abundance, (3) collect distributional information on cetacean species in California waters, and (4) utilize photogrammetry techniques on common dolphins and other delphinid species to determine length and stock identity. Results of the surveys include sighting information for pinnipeds encountered as well as for cetaceans. Overall sighting rates (primary and secondary observers pooled) for cetaceans decreased with increasing Beaufort states. Sighting rates were variable among individual observers. Seasonal distributions of the most commonly sighted cetacean species in California waters appear to have south/north and inshore/offshore components,

which coincided with cold and warm periods, respectively.

Chess, J. R. 1993. Effects of the stipe-boring amphipod *Peramphithoe stypotrupetes* (Corophioidea: Ampithoidae) and grazing gastropods on the kelp *Laminaria setchellii*. J. Crustacean Biol. 13(4):638-646.

The ampithoid amphipod *Peramphithoe stypotrupetes* hollows and infests the stipes of the alga *Laminaria setchellii* after intense grazing of its lamina by gastropods. The intensity of gastropod grazing and subsequent levels of amphipod infestation appear to be correlated with calm ocean conditions. Once established in the stipe, a pair of adult amphipods produces multiple cohorts of offspring, which hollow and kill the plant. At a study site off northern California, an entire bed of the alga was infested and no plants survived. Aspects of the natural history of *P. stypotrupetes* are discussed.

Dailey, M. D., M. L. Fast, and G. H. Balazs. 1993. *Hapalotrema dorsopora* sp.n. (Trematoda: Spirorchidae) from the heart of the green turtle (*Chelonia mydas*) with a redescription of *Hapalotrema postorchis*. J. Helminthol. Soc. Wash. 60(1):5-9.

Davenport, J., G. H. Balazs, J. V. Faithfull, and D. A. Williamson. 1993. A struvite faecolith in the leatherback turtle *Dermochelys coriacea* vandelli: A means of packaging garbage? J. Herpetol. 3:81-83.

DeMartini, E. E. 1993. Modeling the potential of fishery reserves for managing Pacific coral reef fishes. Fish. Bull., U.S. 91(3):414-427.

The potential use of marine fishery reserves (MFRs) for managing fisheries on tropical Pacific coral reefs was assessed with an extension of the Beverton-Holt model. The effects of year-round fishery closures on harvests in adjacent, exploited areas were evaluated. Potential changes in spawning stock biomass per recruit (SSB/R) and yield per recruit (Y/R), when varying fractions of exploitable reef area were closed to fishing, were estimated from published data, approximated natural and fishing mortality rates, size- and maturity-at-age distributions, and "transfer" (emigration and immigration) rates. For select cases, fundamental transfer rates were adjusted for possible density-dependent emigration from closed areas as relative densities decreased in surrounding non-closed areas because of continued fishing. Three hypothetical "fish types" were constructed, bracketing the likely extremes in fundamental transfer rates and related life-history parameters of Pacific coral reef fishes. Simulations corroborate previous observations that MFRs contribute little, if anything, towards increasing Y/R. Results for the highly vagile (mobile) fish type confirm that rapid transfer rates will negate potential gains in SSB/R resulting from closures. At the opposite extreme, small reef philopatriots like damselfishes would almost never be harvested, because of negligible transfer rates, unless the MFR was periodically opened to fishing. The simulations suggest that the SSB/Rs of moderately vagile fishes are most likely to benefit from MFRs, because moderate vagility allows biomass to accumulate within the closure despite harvesting in the non-closed area. Results further suggest that growth rate, fishing effort in the non-closed (open) area, natural mortality, and maturity and harvesting schedules importantly influence the potential of MFRs to augment SSB when transfer rates are low to moderate.

DeMartini, E. E., D. M. Ellis, and V. A. Honda. 1993. Comparisons of spiny lobster, *Panulirus marginatus*, fecundity, egg size, and spawning frequency before and after exploitation. Fish. Bull., U.S. 91:1-7.

DiNardo, G. T. 1993. Statistical guidelines for a pilot observer program to estimate turtle takes in the Hawaii longline fishery. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-190, 40 p.

Statistical guidelines are described for the development of a pilot scientific observer sampling program to collect turtle interaction data from the Hawaii longline fishery. The best available data are presented and potential sources of variability in longline turtle take rates are discussed. A stratified sampling design for a pilot survey is developed based on time and target species. An array of sample size choices for the pilot program is presented covering a range of tolerance levels and confidence levels for estimation of total turtle take.

Eckert, K. L. 1993. The biology and population status of marine turtles in the North Pacific Ocean. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-186, 156 p.

Eliason, J. J., J. R. Henderson, and M. A. Webber. 1993. Hawaiian monk seal observations at French Frigate Shoals, 1985. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-187, 46 p.

Finn, M., J. R. Henderson, B. L. Becker, and T. J. Ragen. 1993. The Hawaiian monk seal and green turtle at Pearl and Hermes Reef, 1990 and 1991. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-182, 29 p.

Gilpatrick, J. W., Jr. 1993. Method and precision in estimation of dolphin school size with vertical aerial photography. Fish. Bull., U.S. 91(4):641-648.

Field and laboratory procedures were used to acquire dolphin school size estimates from vertical aerial photographs. Multiple photographs were taken of 48 separate schools during a 1989 eastern tropical Pacific (ETP) dolphin abundance survey. During a 12-week "counting period," three readers did independent counts of dolphins in the photographs. For each school, the best photograph imagery was selected and the mean of the three independent counts was used to estimate its "true" size. The coefficient of variation (CV) for school size estimates (between-reader preci-

sion) averaged 5.4 percent and ranged between 1.2 and 14.6 percent. Most (92 percent) of the schools were estimated with precision, resulting in a CV of less than 9.0 percent. Within-reader CV averaged 3.5 percent and ranged 1.4-7.1 percent, indicating that readers were quite precise. To test if reader methods were constant during the counting period, temporal trends in estimates were tested by linear regression analyses and a repeated-counts experiment with repeated measures analysis of variance (RM-ANOVA). Regression analyses indicated no significant temporal trends or bias in the deviation of counts from the means. The RM-ANOVA showed a significant "reader with time" interaction which was attributed to the relatively high variability between readers in counts made at the start of the experiment. Results suggested that methods were constant and counts were precise after an initial "warm-up" counting session.

Haight, W. R., J. D. Parrish, and T. A. Hayes. 1993. Feeding ecology of deepwater lutjanid snappers at Penguin Bank, Hawaii. Trans. Am. Fish. Soc. 122:328-347.

Hewitt, R. P., and D. A. Demer. 1993. Dispersion and abundance of Antarctic krill in the vicinity of Elephant Island in the 1992 austral summer. Mar. Ecolog. Prog. Ser. 99:29-39.

Hinckley, S., K. Bailey, S. Picquelle, M. Yoklavich, and P. Stabeno. 1993. Age-specific mortality and transport of larval walleye pollock, *Theragra chalcogramma*, in the western Gulf of Alaska. Mar. Ecol. Prog. Ser. 98:17-29.

Holts, D., and D. W. Bedford. 1993. Horizontal and vertical movements of the shortfin mako shark, *Isurus oxyrinchus*, in the southern California bight. Aust. J. Mar. Freshwater Res. 44:901-909.

Recreational and commercial fishing effort directed at the shortfin mako shark, *Isurus oxyrinchus*, off the coast of southern California increased markedly in the mid 1980s. However, very little is known about the population size, stock structure or movements of these sharks in the northern Pacific. It is important to determine their role in these waters because the southern California bight may be an important pupping and nursery area for shortfin mako sharks. Acoustic telemetry was used to identify short-term horizontal and vertical movements of three shortfin mako sharks in the Southern California Bight during the summer of 1989. All three sharks were 2-year-old juveniles and were tracked for periods of from 18 to 25 hours. They spent 90 percent of their time in the mixed layer, with only infrequent excursions below the thermocline. Vertical and horizontal movements did not indicate any diel activity pattern associated with distance to the shore or nearby islands or with bottom topography.

Humphreys, R. L., Jr., M. A. Crossler, and C. M. Rowland. 1993. Use of a monogenean gill parasite and feasibility of condition indices for identifying new recruits to a seamount population of armorhead *Pseudopentaceros wheeleri* (Pentacerotidae). Fish. Bull., U.S. 91(3):455-463.

Efforts to develop a method of identifying new recruits to the demersal armorhead *Pseudopentaceros wheeleri* population at Southeast (SE) Hancock Seamount were initiated by an examination of epipelagic and seamount (SE Hancock) armorhead for differences in macroparasites as well as hepatosomatic and visceral fat-somatic indices. Of the two condition indices, the hepatosomatic index held the most potential but was considered too labile because pre-recruits probably experience decreases which vary according to energetic demands during seamount migration. The monogenean gill parasite *Microcotyle macropharnyx* was highly prevalent among seamount individuals in all sampling periods but absent from epipelagics. Based on probable rapid infection and maturation, identification of new recruits was based on the absence of mature *M. macropharynx*. Results indicate that significant ongoing recruitment occurred only during the late spring to midsummer sampling periods, and the mean FI (body depth relative to fork length) of new seamount recruits was lower than that of comparable epipelagics.

Jackson, A. R. 1993. Summary of 1989 U.S. tuna-dolphin observer data. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-183, 31 p.

Jacobson, L. D., and C. J. Thomson. 1993. Opportunity costs and the decision to fish for northern anchovy. N. Amer. J. Fish. Manage. 13:27-34.

Jones, D. R., R. W. Brill, and P. G. Bushnell. 1993. Ventricular and arterial dynamics of anaesthetised and swimming tuna. J. exp. Biol. 182:97-112.

Cardiovascular dynamics of tuna were investigated by recording blood pressures and flows in the central circulation of both anaesthetised and swimming individuals. In anaesthetised fish (N=5), heart rate, stroke volume, ventricular diastolic pressure, ventral aortic pressures, and blood flow in the ventral aorta were measured. Dorsal aortic pressure and flow, pressure polsatility (pulse pressure as a proportion of mean pressure), total peripheral resistance, and impedance modulus for the ventral aorta were also measured. Impedance phase was negative, meaning that flow leads pressure at all harmonics. In swimming yellowfin tuna (N=5), heart rate and ventral and dorsal aortic pressures were measured, as well as average stroke volume in three swimming kawakawa. Data from swimming fish were within the range obtained for anaesthetised tuna. A simple model of the fish circulation consisting of two sets of compliant and resistive elements coupled in series (a second-order *RC* network) gave reasonable predictions of arterial pressure-flow relationships. The researchers concluded that a "Windkessel" dominates central cardiovascular dynamics of tuna despite heart rates and blood pressures that fall in the mammalian range.

Lee, M. M., L. K. Timme, R. VanToorenburg, and B. L. Becker. 1993. The Hawaiian monk seal on Lisianski Island, 1988 and 1990. U.S. Dep. Commer., NOAA Tech. Memo., NMFS-SWFSC-179, 33 p.

Lee, T. 1993. Summary of cetacean survey data collected between the years of 1974 and 1985. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-181, 184 p.

Lo, N. C.-H., J. R. Hunter, H. G. Moser, and P. E. Smith. 1993. A daily fecundity reduction method of biomass estimation with application to Dover sole *Microstomus pacificus*. Bulletin of Marine Science 53(2):842-863.

A daily fecundity reduction method was applied to *Microstomus pacificus*, commonly known as Dover sole, a pleuronectid flatfish of the upper continental slope (200 to 1,500 m) of the west coast of North America. This method was developed for estimating adult biomass of fishes with determinate annual fecundity and utilizes the daily decline in reproductive potential of the population and numbers of planktonic eggs. Daily decline in reproductive potential was estimated from the decline of the product of the standing stock of advanced oocytes and the numbers of females with reproductively active ovaries. Daily production of planktonic eggs was estimated from the numbers of eggs in quantitative oblique plankton tows. We describe the survey design, data assembly, statistical estimation procedures, and the possible biases due to the limitation of surveys.

MacCall, A. D. 1993. Overview paper: Advice for stock rebuilding. *In* Rosenberg, Andrew (ed.), Defining overfishing—defining stock rebuilding. Report of the Second Annual National Stock Assessment Workshop, p. 47-59. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-F/SPO-8.

Macewicz, B. J., and J. R. Hunter. 1993. Spawning frequency and batch fecundity of jack mackerel, *Trachurus symmetricus*, off California during 1991. Calif. Coop. Oceanic Fish. Invest. Rep. 34:112-121.

MacFarlane, R. B., E. C. Norton, and M. J. Bowers. 1993. Lipid dynamics in relation to the annual reproductive cycle in yellowtail rockfish, *Sebastes flavidus*. Can. J. Fish. Aquat. Sci. 50(2):391-401.

Miya, R. K., and G. H. Balazs. 1993. Ecology and conservation of green turtles in the nearshore waters of Waikiki Beach. 'Elepaio 53(2):9-13.

Moser, H. G., and P. E. Smith. 1993. Larval fish assemblages and oceanic boundaries. Bulletin of Marine Science 53(2):283-289.

———. 1993. Larval fish assemblages of the California Current region and their horizontal and vertical distributions across a front. Bulletin of Marine Science 53(2):645-691.

Cruises of the California Cooperative Oceanic Fisheries Investigations occupied 31,214 survey stations in a one million km^2 area off California and Baja California during 1951-1984. Recurrent group analysis of 249 larval fish taxa placed 36 taxa in 12 recurrent groups. These groups reflect the oceanographic complexity of the region with subarctic-transitional, eastern tropical Pacific (ETP), and central water mass components. The major shorefish recurrent group is associated with the large shelf area of Sebastian Viscaino Bay off central Baja California. Cluster analysis using correlation coefficients of abundance as the measure of distance and principal component analysis produced groupings that agreed in general with groups formed by presence-absence analysis. Environmental effects on these groups were studied by examining changes in horizontal and vertical distribution across a frontal region. Plankton samples from the FRONTS 85 cruise conducted in July, 1985, southwest of the Southern California Bight, allowed the researchers to investigate the fine-scale distribution of assemblages across a semipermanent frontal zone separating cold eutrophic water to the north from relatively warm, oligotrophic water to the south. Ichthyoplankton samples from a 120-nmi transect across the front, including 42 oblique bongo tows and 8 Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS) tows to 1,000 miles, demonstrated 1) the transition between subarctic-transitional and ETP/central water mass species, and 2) distinctly different patterns of vertical distribution for the same species at the north and south sides of the front.

Norton, J. G., and D. R. Mclain. 1993. Year-to-year changes of vertical temperature distribution in the California Current region: 1954 to 1986. Proceedings of the Ninth Annual Pacific Climate Workshop, April 21-24, 1992. Redmond, K. T., and V. L. Tharp (eds.), California Department of Water Resources, Interagency Ecological Studies Program Report CL/PACLIM92-34.

Okihiro, M. S., J. A. Whipple, J. M. Groff, and D. E. Hinton. 1993. Chromatophoromas and chromatophore hyperplasia in Pacific rockfish (*Sebastes* spp.). Cancer Res. 53:1761-1769.

Parrish, F. A., and R. B. Moffitt. 1993. Subsurface fish handling to limit decompression effects on deepwater species. Mar. Fish. Rev. 54(3):29-32.

Pearson, D. E., D. A. Douglas, and B. Barss. 1993. Biological observations from the Cobb Seamount rockfish fishery. Fish. Bull., U.S. 91(3):573-576.

Perrin, W. F., and J. E. Heyning. 1993. Rostral fusion as a criterion of cranial maturity in the common dolphin, *Delphinus delphis*. Mar. Mammal Sci. 9(2):195-197.

Perryman, W. L., and M. S. Lynn. 1993. Identification of geographic forms of common dolphin, *Delphinus delphis*, from aerial photogrammetry. Mar. Mammal Sci. 9(2):119-137.

Philbrick, V. A., P. C. Fiedler, and S. B. Reilly. 1993. Report of ecosystem studies conducted during the

1991 California Coastal Marine Mammal Survey aboard the research vessel *McArthur*. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-184, 41 p.

In 1991, the Marine Mammal Division of the Southwest Fisheries Science Center conducted a marine mammal survey in the coastal waters of California. The study was prompted by evidence of an increase in cetacean and pinniped mortality due to gillnet fisheries in this region. The survey was conducted in four legs of approximately 22 days each, from the NOAA vessel *McArthur*. The survey's main objectives were to estimate the abundance and understand the distribution of cetacean and pinniped species commonly found in the survey area. However, another objective was to collect physical, biological, and oceanographic data in the survey area to aid scientists in understanding the biological basis of the distribution and abundance of animals in that area. The report includes a summary of environmental and biological data collected; linear regressions of standard 24-hour integrated productivity values and 6-, 12-, and replicate 24-hour values; primary productivity data; locations of conductivity-temperature-density (CTD) stations and expendable bathythermograph (XBT) deployments; and sea surface temperature, salinity, and chlorophyll *a* data.

Philbrick, V. A., P. C. Fiedler, S. B. Reilly, R. L. Pitman, and L. T. Ballance. 1993. Report of ecosystem studies conducted during the 1992 eastern tropical Pacific common dolphin survey on the research vessels *David Starr Jordan* and *McArthur*. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-180, 74 p.

Prager, M. H., and A. D. MacCall. 1993. Detection of contaminant and climate effects on spawning success of three pelagic fish stocks off southern California: northern anchovy, *Engraulis mordax*; Pacific sardine, *Sardinops sagax*; and chub mackerel, *Scomber japonicus*. Fish. Bull., U. S. 91(2):314-331.

Rogers, J. B., and J. R. Bence. 1993. Status of the chilipepper rockfish stock in 1993. Appendix D. *In* Status of the Pacific Coast groundfish fishery through 1993 and recommended acceptable biological catches for 1994, p. D1-D23. Pacific Fishery Management Council, Portland, Oregon.

Rogers, J. B., and W. H. Lenarz. 1993. Status of the widow rockfish stock in 1993. Appendix B. *In* Status of the Pacific Coast groundfish fishery through 1993 and recommended acceptable biological catches for 1994, p. B1-B37. Pacific Fishery Management Council, Portland, Oregon.

Schroeter, S. C., J. D. Dixon, J. Kastendiek, R. O. Smith, and J. R. Bence. 1993. Detecting the ecological effects of environmental impacts: A case study of kelp forest invertebrates. Ecological Applications 3:331-350.

Segerson, K., and D. Squires. 1993. Capacity utilization under regulatory constraints. Review of Economics and Statistics 75(1):76-85.

Seki, M. P. 1993. The role of the neon flying squid, *Ommastrephes bartrami*, in the North Pacific pelagic food web. Bulletin 53 (II)—North Pacific Commission 53:207-215.

Trophic relationships of neon flying squid, *Ommastrephes bartrami*, are examined during their summer occupation of waters within the Subarctic Frontal Zone and after their spawning migration south to subtropical waters. An examination of 174 stomachs from driftnet-caught *O. bartrami* near the Subarctic Boundary revealed many squid with empty stomachs and a high incidence of cannibalism. Squid with stomach contents fed exclusively on fishes (mainly micronektonic mesopelagic myctophids and stomiiformes) and other cephalopods. No significant difference was found between the diets (nor the degree of cannibalism) of *O. bartrami* when the stomach contents of squid taken near the Subarctic Boundary were compared with those of mature females collected during the winter in the subtropics. Stomach contents are also described for blue sharks, *Prionace glauca*, captured by surface longlines in the North Pacific Transition Zone. Their most important diet items were myctophids, small gonatid squids, and *O. bartrami*. *Ommastrephes bartrami*, however, appeared important only among the larger sharks caught. Results of these diet studies are discussed together with a review of pertinent literature to clarify the role of *O. bartrami* in the North Pacific pelagic food web.

———————. 1993. Trophic relationships of *Ommastrephes bartramii* during winter migrations to subtropical waters north of the Hawaiian Islands. *In* Okutani, T., R. K. O'Dor, and T. Kubodera (eds.), Recent advances in cephalopod fisheries biology, p. 523-529. Tokai University Press, Tokyo.

One of the most widely distributed and abundant nektonic animals in the epipelagic North Pacific Ocean is the Pacific pomfret, *Brama japonica*. Seki presents various ecological and life history aspects of *B. japonica* based on 148 larval and juvenile specimens collected with a midwater trawl at eight locations north of the Hawaiian Islands near the Subtropical Frontal Zone (STFZ). Most *B. japonica* were caught within the mixed layer in water temperatures of 17.5-19.8 °C; their distribution was limited to the south by the 21 °C isotherm. Satellite data depicting the location of the STFZ, in conjunction with catch data, indicate that larval and juvenile *B. japonica* were typically distributed to the north of the Subtropical Front. Ages and growth rates of 32 larvae and juveniles were determined through analysis of otolith microstructures: Estimated ages were 1-2 months, and estimated growth rate was 0.354 millimeters d^{-1} for 11-24 millimeters standard length; fish hatching dates based on back-calculated age estimates were January 2-30, 1991. An examination of the feeding habits of pomfrets caught

by driftnet near the STFZ revealed that most of the stomachs were empty; hyperiid amphipods along with other unidentified crustaceans were predominant in the stomachs that contained prey.

Silberberg, K. R., and P. B. Adams. 1993. A comparison of the recreational and commercial fisheries for lingcod (*Ophiodon elongatus*) off the Pacific coast of the United States, and a description of the recreational lingcod fishery. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-193, 48 p.

Recreational lingcod (*Ophiodon elongatus*) landings data from the Pacific coast of the United States were compared to commercial landings data for the years 1980 through 1989. Furthermore, Marine Recreational Fishery Statistics Survey (MRFSS) estimates were summarized with respect to the number and weight of fish landed, fishing modes, and length frequencies to assess their adequacy for management. Comparison of recreational and commercial landings showed that in the southern and northern California subregions, recreational landings accounted for 69 percent and 46 percent of the combined recreational and commercial landings, respectively. However, in the Oregon and Washington subregions, recreational landings only accounted for 16 percent of the combined landings. There were no annual trends in recreational lingcod landings. The southern California subregion had a decreasing trend in lingcod landings, but the trend was based on a single, particularly high 1980 estimate. Northern California landings were erratic, but with a slight downward trend. Oregon and Washington subregions had no annual trends for recreational landings. Examining the total number of recreationally caught lingcod landed by fishing mode showed that at least 61 percent of lingcod were landed from private/rental boats, and 32 percent from party/charter boats, with the remaining 7 percent being landed from shore. The average fork length of lingcod landed ranged from 602-651 millimeters, with a coastwide average of 634 millimeters.

Skillman, R. A., C. H. Boggs, and S. G. Pooley. 1993. Fishery interaction between the tuna longline and other pelagic fisheries in Hawaii. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-189, 46 p.

Smith, P. E. 1993. Balancing sampling precision and fisheries management objectives: minimal methods. Bulletin of Marine Sciences 53(2):930-935.

Density-dependent and environmental effects on population size are both too weak to be useful for short-term fishery management. Year-to-year variation of recruitment rate may be of the same order of magnitude as measurement uncertainty and population changes may have to be sustained for 2 to 3 years to be detectable using the precision available from current techniques. As fishing rates accelerate, the dependence of the fishable biomass on recruitment is increased. Prerecruit survival and growth may be more episodic than adult survival and fecundity. The episodic nature of recruitment combined with higher fishing rates may make more frequent biomass estimates necessary. When variable recruitment and high instantaneous total mortality rates reach a certain level, effective fisheries management will require development of recruitment prediction procedures in addition to virtual population and biomass monitoring. Annual biomass surveys may be redundant because many stocks contain several year-classes. The costs of implementing recruitment prediction and systems to monitor biomass may be a significant fraction of the value of the added catch and this should be considered during management planning.

Squire, J. L., Jr. 1993. Relative abundance of pelagic resources utilized by the California purse-seine fishery: Results of an airborne monitoring program, 1962-90. Fish. Bull., U.S. 91(2):348-361.

Taylor, B. L. 1993. "Best" abundance estimates and best management: Why they are not the same. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-188, 20 p.

Taylor, B. L., and D. P. DeMaster. 1993. Implications of non-linear density dependence. Marine Mammal Science 9(4):360-371.

Ranges of the ratio of maximum net productivity level (MNPL) to carrying capacity (*K*) are explored in general models for pinnipeds and odontocetes. MNPL/*K* is used in management of marine mammals but no empirical evidence exists to limit the range of values expected. Density dependent changes in age-specific birth and death rates have been used to infer MNPL/*K*. Nonlinearities in these rates do not translate directly to population growth curves. The simple models demonstrate that (1) density dependence is likely to involve more than a single parameter (such as birth rate), (2) MNPL/*K* depends on biological limits on ranges of fecundity and survival rates, and (4) the magnitude and sign of bias incurred by inferring MNPL/*K* from functional forms of single parameters cannot be determined. Given current empirical evidence, the range of MNPL/*K* for marine mammals as a group is large. Although MNPL/*K* values can be generated through models which account for single species ranges for birth and death rates and maximum population growth rate.

Taylor, B. L., and T. Gerrodette. 1993. The uses of statistical power in conservation biology: The vaquita and Northern Spotted Owl. Conservation Biology 7(3):489-500.

Van Toorenburg, R. A., W. G. Gilmartin, and J. R. Henderson. 1993. Composition of the Hawaiian monk seal at Kure Atoll, 1990. Pac. Sci. 47:211-214.

Wetherall, J. A., G. H. Balazs, R. A. Tokunaga, and M. Y. Y. Yong. 1993. Bycatch of marine turtles in North Pacific high-seas driftnet fisheries and impacts on the

stocks. Bulletin 53 (II)—North Pacific Commission 53:519-538.

Four species of marine turtles, all listed as threatened or endangered by the International Union for the Conservation of Nature, have been documented in the bycatch of North Pacific high-seas driftnet fisheries. Bycatch rate data collected by observers, combined with driftnet fleet effort data, indicate a total marine turtle bycatch of about 6,100 turtles in 1990. The overall minimum marine turtle mortality due to driftnet entanglement in 1990 was about 1,700 turtles. Most of the mortalities were of loggerheads taken in the large-mesh driftnet fisheries of Japan and Taiwan. A reliable assessment of driftnet fishery impacts is hampered by lack of essential data on marine turtle population status and dynamics.

Wetherall, J. A., and M. Y. Y. Yong. 1993. A comparison of driftnet fishery bycatch estimation methods based on empirical bootstrap distributions. Bulletin 53 (II)—North Pacific Commission 53:359-365.

Two methods were compared for estimating the total bycatch of albacore, *Thunnus alalunga*, skipjack tuna, *Katsuwonus pelamis*, and blue shark, *Prionace glauca*, in the 1990 Japanese driftnet fishery for neon flying squid, *Ommastrephes bartrami*: (1) a standard method that expands the arithmetic mean of sample bycatch rates, and (2) the Pennington method, which expands the delta-lognormal estimator of the mean bycatch rate. Bootstrap distributions of the two estimators consistently showed that the Pennington method estimated higher total bycatch and wider approximate confidence intervals for total bycatch. The results agree with other findings published recently, indicating that the Pennington estimator is not robust with respect to the key assumption of lognormality in the positive bycatch rates.

Wibbels, T., G. H. Balazs, D. W. Owens, and M. S. Amoss, Jr. 1993. Sex ratio of immature green turtles inhabiting the Hawaiian Archipelago. J. Herpetol. 27(3):327-329.

Wilson, C. D., and G. W. Boehlert. 1993. Population biology of *Gnathophausia longispina* (Mysidacea: Lophogastrida) from a central North Pacific seamount. Mar. Biol. 115:537-543.

Yoshimoto, S. S., and R. P. Clarke. 1993. Comparing dynamic versions of the Schaefer and Fox production models and their application to lobster fisheries. Can. J. Fish. Aquat. Sci. 50(1):181-189.

Approved by Science and Research Director, SWR

This list is for those publications approved by the Science and Research Director in November and December 1993 for all laboratories.

Aguirre, A. A., G. H. Balazs, B. Zimmerman, and F. D. Galey. Organic contaminants and trace metals in the tissues of green turtles (*Chelonia mydas*) afflicted with fibropapillomas in the Hawaiian Islands. For consideration for publication in Marine Pollution Bulletin.

Akin, P. A., R. B. Miller, and K. M. Peltier. Techniques for the preparation and examination of reproductive samples collected from dolphin species in the eastern tropical Pacific. For consideration for publication in NOAA Technical Report Series.

Alcorn D. J., and R. L. Westlake. The Hawaiian monk seal on Laysan Island, 1986. For consideration for publication in NOAA Technical Report Series.

Benetti, D. D., R. W. Brill, and S. A. Kraul. The standard metabolism, heart rate and red muscle distribution of dolphin, *Coryphaena hippurus*. For consideration for publication in Fishery Bulletin, U.S.

Blood, B. M., A. C. Matarese, and M. M. Yoklavich. Embryonic development of walleye pollock, *Theragra chalcogramma*, from Shelikof Strait, Gulf of Alaska. For consideration for publication in Fishery Bulletin, U.S.

Brill, R. W. A review of temperature and oxygen tolerance studies of tuna, and their relevance to fisheries oceanography, movement models, and stock assessments. For consideration for publication in Fisheries Oceanography.

Brill, R. W., G. H. Balazs, K. N. Holland, R. K. C. Chang, and S. Sullivan. Submergence intervals, movements, and habitat use of normal and tumor-afflicted Hawaiian green turtles (*Chelonia mydas*) determined by ultrasonic telemetry. For consideration for publication in Canadian Journal of Zoology.

Demer, D. A., and R. P. Hewitt. Bias in acoustic biomass estimates of *Euphausia superba* due to diel vertical migration. For consideration for publication in Deep-Sea Research.

Ellis, D., and E. E. DeMartini. Evaluation of a video camera technique for indexing abundances of juvenile pink snapper (*Pristipomoides filamentosus*, F. Lutjanidae) and other Hawaiian insular shelf fishes. For consideration for publication in Fishery Bulletin, U.S.

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